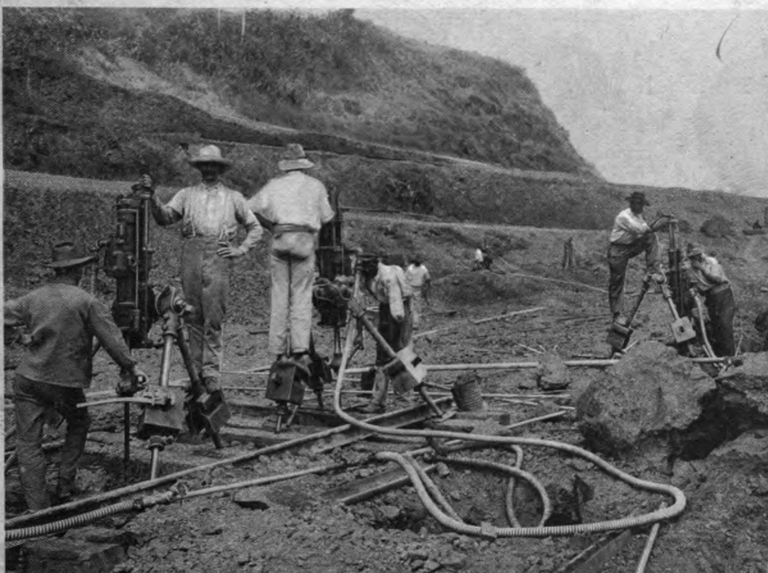
MINE AND QVARRY

#2 may

VOL. I. NO. 1. MAY, 1906

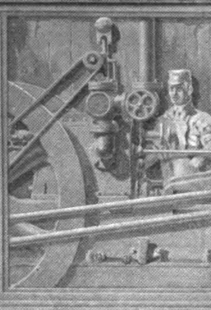


SULLIVAN ROCK DRILLS IN THE BAS OBISPO CUT, PANAMA CANAL

Modern Methods at an Illinois Mine

Cleaving Granite by Compressed Air

The Power Extension of the Chicago Drainage Canal



PVBLISHED BY THE SVLLIVAN MACHINERY CO. RAILWAY EXCHANGE BVILDING, CHICAGO.

TABLE OF CONTENTS

	Page
Editorial	1
Rock Excavation at Panama	3
Modern Methods at an Illinois Mine . .	3
Diamond Drilling	9
The Power Extension of the Chicago Drainage Canal	11
Low Cost of Compressing Air for Drills . .	23
Cleaving Granite by Compressed Air . .	23
Suggestions for Operation of Rock Drills . .	28

MINE AND QUARRY

A Quarterly Bulletin of News for Superintendents, Managers, Engineers and Contractors

Published by the Advertising Department of the Sullivan Machinery Company

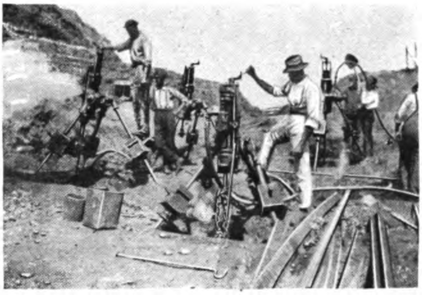
Address all Communications to **Mine and Quarry,** *Railway Exchange, Chicago*

Sent to any address upon request

Vol. 1. No. 1. MAY, 1906.

THE object of "Mine and Quarry" is to familiarize its readers with the different classes of machinery manufactured by the Sullivan Machinery Co. This is frankly stated at the outset, to avoid misconception in any quarter. This aim will be attained by descriptions of engineering, mining and quarrying undertakings of special interest, in which the various machines have been or are employed; by mention and illustration of new machines and of improvements to existing types; and by discussion and suggestion regarding the best practice in the application, use and care of machines under different conditions. Communications, suggestions and inquiries from readers will be welcomed and will receive careful attention. In conclusion, "Mine and Quarry" hopes to be of service to its chosen public, by giving circulation to news of modern methods applied to engineering, quarrying and mining work.

[Readers are requested to notify "Mine and Quarry" of any correction or change in address, using the enclosed post card for the purpose.]



Two views of the Bas Obispo Cut: Sullivan Drills at work

Bas Obispo Cut: Sullivan Drills in foreground. Steam shovel in bottom of cut; Churn Drill in background

The Culebra Cut, North End

Workmen's Quarters, Culebra

ROCK EXCAVATION AT PANAMA.

CULEBRA, C. Z., PANAMA,
March 15, 1906.

MINE AND QUARRY:

In reply to your inquiry as to the amount of rock work being done upon the canal, I may say that rock excavation is in progress at several different points between Bas Obispo and Pedro Miguel. The most important undertaking from the point of view of the amount and hardness of the rock to be removed, is that at Bas Obispo. At this point, 24 Sullivan tappet valve drills, class UH-11, with 3⅝ in. cylinders, have been in use for the past six months, drilling holes from 20 to 27 ft. in depth, together with three churn drills used to handle a few holes from 30 to 40 ft. deep on the upper benches. This Bas Obispo cut, begun by the French and now being greatly widened and deepened by the Americans, is an all rock formation, hard and blocky, making it difficult to drill. [Our frontispiece shows the Sullivan drills at work in this cut and several photographs reproduced herewith illustrate further the operations at Bas Obispo.—ED.]

From Bas Obispo going south along the line of the canal, no heavy rock is encountered till the Culebra cut is reached. At Empire, however, some few miles this side of Culebra, about 15 steam drills are at work in a soft rock formation, widening the old canal, and at about the same point some twenty-five churn drills are working, principally where clay is encountered and where the bench runs to a depth of 37 ft.

At the present time, no steam drills are at work in the Culebra cut, although some hand drilling is being done on a section of rock pitching about 60 degrees from the horizontal. The class of formation met with in this cut is extremely varied, a large percentage of it, however, being rock, as soft as soapstone in places and like a trap rock in others, with an occasional vein of quartz. Below Culebra a few steam drills are at work near Paraiso, the same drills just having finished drilling in the rock section at Pedro Miguel.

The reciprocating drills in use, some 55 in number, are all at the present time operated by steam, which power will later on give place to compressed air, when the air compressor installations are complete and the necessary pipe laid.

Hoping this information will be of interest, I remain

Yours truly,

G. M. BERTRAM.

MODERN METHODS AT AN ILLINOIS MINE.

From "FUEL"

The Illinois coal operators are as wide awake a body of men as can be found in the coal industry anywhere, and the new mines which are constantly going upon the shipping

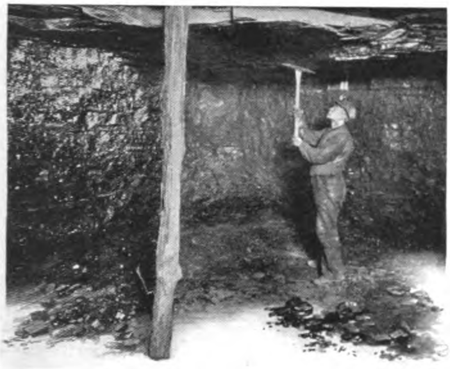
Tipple, Power House and Fan House, St. Louis & O'Fallon Coal Co.

basis, bear witness in their economical management and splendid equipment, to the enterprise and foresight of their owners. The No. 2 mine of the St. Louis and O'Fallon Coal Co., near East St. Louis, is an excellent example of late practice in this respect. The company's general offices are in the Missouri Trust Bldg., St. Louis, and its officers are Mr. Jas. M. Browning, President, Mr. L. A. Browning, Vice President, Mr. C. A. Wall, Secretary and Treasurer, and Mr. John T. Taylor, General Manager at East St. Louis.

The company has for some time been operating mine No. 1, which is now shipping between 1,700 and 1,800 tons per day. All coal at this mine is won by hand work. In opening mine No. 2 it was desired to make the mine one of the largest in the state, and to produce fuel of as high a grade as possible, for the market. In order to accomplish these results, the company has spared no pains or expense in their manner of opening the mine, or in installing equipment of the most improved type.

Page 4 shows the power plant, fan house, head frame and tipple, with the machine shop and store house in the back ground. The buildings are of heavy brick and steel girder construction, the roofs and siding for the tipple and head frame, being of corrugated iron. The stack shown, is 90 ft. in height.

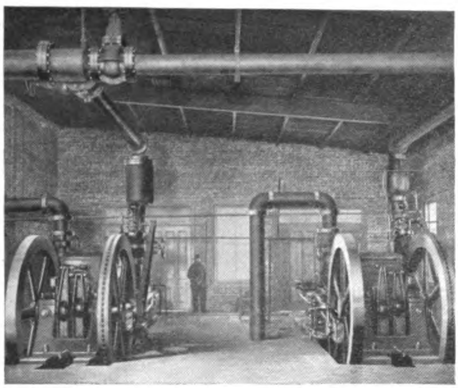
The vein (see page 5) is 7 ft. in thickness, of a high grade of standard Illinois coal. It is reached by two shafts (with two compartments each), 18 feet by 9 feet in the clear and 206 ft. deep, one for hoisting and one for ventilating purposes. The roof over-lying the coal is composed of 17 ft. of hard black rock, on top of which slate and shale occur. Props are seldom needed. The entries are driven 20 ft. in width, and the rooms are 35 ft. wide. The track gauge of the mine is 42 in., and 42 pound rails are used throughout. At present mule haulage is in use, but will be replaced by electricity as soon as the mine is sufficiently opened up. The pit cars have a capacity, when loaded level, of $2\frac{1}{2}$ tons, but in practice are loaded to $3\frac{1}{2}$ or 4 tons on the aver-



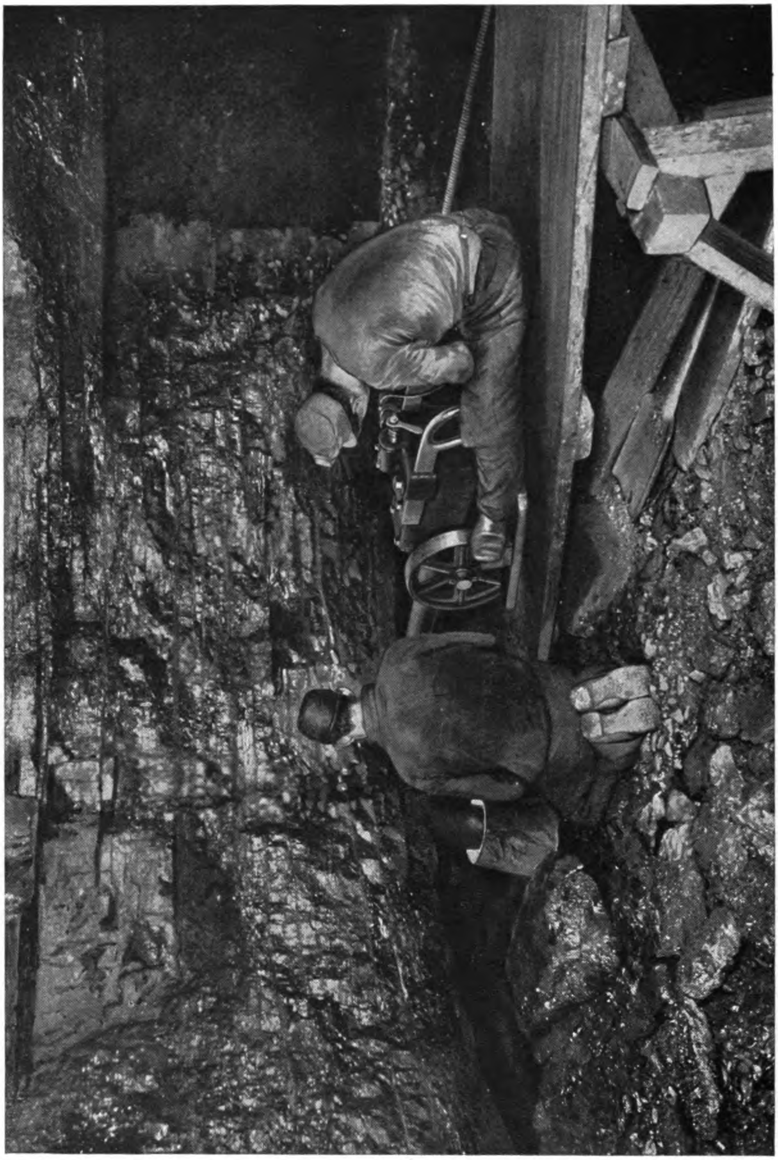
Seven Feet of Good Coal

age, as shown by the tally sheets of the weighmen.

In order to secure the greatest possible amount of lump, the coal is not shot from the solid as in mine No. 1, but is undercut throughout by pick mining machines of the Sullivan class 5 type. These machines undercut the coal to a depth of 5½ ft., and thus make it possible to shoot the coal satisfactorily with a very light charge of powder. Page 6 shows one of these machines at work undercutting and on page 8 is shown a room which has been cut and is ready for shooting. These undercutters have a 5⅛ in. cylinder, and weigh 825 pounds. This particular type has been very generally adopted in Illinois mines, and has proven very economical of power and repairs and convenient to handle. By their use it is possible to open up a mine nearly three times as rapidly as by hand. They are operated double shift, thus providing a constant supply of coal as great as the loaders can handle. These machines average from 70 to 75 tons per shift of 8 hours in coal of this height, i. e., 6½ to 7 ft. An expert runner, however, recently cut 1382 tons in 12 eight-hour shifts. The pick machines are supplied with air from two Sullivan straight line air compressors (see below) furnishing at their rated speed of 100 R. P. M., approximately 5,000 cu. ft. of free air per minute. These compressors, as well as the pick machines described above, are manufactured by the Sullivan Machinery Co., of Chicago. The compressors have 28 in. simple steam cylinders, and the air is compressed in two stages, the cylinders being 30 in. and 18 in. in diameter respectively, with a common stroke of 30 inches. The steam slide valve gear is controlled by a Meyer adjustable cut-off with Richardson balance. The free air supply is conducted from outside of the engine room to the compressors so as to secure freedom from dust and moisture, and enters both the high



The Sullivan Straight Line Air Compressors



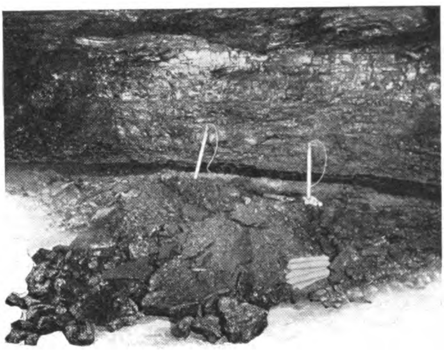
Sullivan Pick Machine at Work, St. Louis & O'Fallon Coal Company

and low pressure cylinders through rotary or Corliss valves positively driven from an eccentric pin on the engine shaft. These valves afford a wide, direct opening to the cylinder, and operate very quickly, so that the air has no opportunity to become heated in entering the cylinder, and clearance losses are minimized. Heating of the air during compression is further guarded against by heavy water jackets on the cylinders and cylinder heads, and by a large intercooler, in which the air meets the cold water tubes three times in passing from the low to the high pressure cylinder. Self-acting poppet discharge valves are employed, so set as to reduce clearance losses to the minimum, and removable by hand for inspection. The air discharge pipes from both compressors are 7 inches in diameter and meet in a single pipe 9 inches in diameter, leading to the receiver. The receiver is located outside the engine room, and is of the horizontal type, 56 inches in diameter by 20 ft. long. Gate valves between the compressors and receiver permit the cutting out of either compressor if desired. The main pipe line running from the receiver to the bottom of the shaft is 10 inches in diameter. It is here divided into two six-inch lines, each six-inch line running into a 26-inch by 14-foot horizontal receiver, at this point, thus avoiding all fluctuations in pressure at the machines, and effectually removing entrained water. To accomplish the latter purpose, additional water traps are placed at several points along the pipe lines. A six-inch line comes out of each receiver, extending along the main entry. The cross-entry pipes are three inches in diameter, and the room pipes supplying the machines are one and one-half inches, thus providing amply against loss in pressure due to friction.

In order to secure the large output desired for this mine, i. e. 3,500 tons per day, and to handle the unusually large pit cars referred to above, a hoist was installed with seven ft. winding drums, and two engines with 24x36 inch cylinders having a capacity of 4,000 tons per day. The steel ventilating fan is in a separate building to the extreme right in the cut on page 4, and is 22 ft. in diameter, which is more than adequate for any extent to which underground workings may be carried. Power for the hoist, fan, compressors, etc., is supplied by two batteries of horizontal tubular high pressure boilers, representing a total horse power of 1,200.

For carrying out the object of the company to have as large a capacity of as high a grade of product as possible, the design of the tipple and screens is particularly noteworthy. This portion of the plant was designed and erected by Roberts & Schaefer Co., consulting and constructing engineers, of Chicago. The tower portion of the tipple,

down to the line of offset on the ground, shown in the cut on page 4, is built entirely separate from that portion of the tipple over the railroad tracks, which supports the screens, so that the vibration from the cables is not transmitted through the tower to the screens, nor is vibration from the screens carried through their supporting structure back to the tower. This structure, as well as that of the tipple, is entirely of steel and is made very



A Machine Mined Room Ready for Blasting

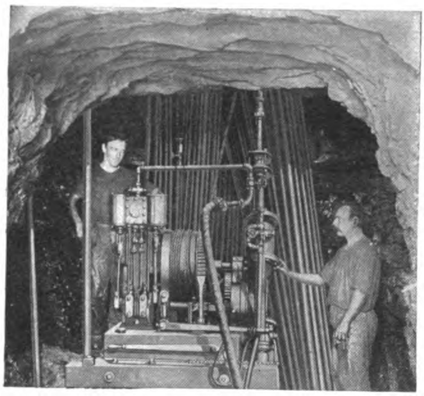
heavy and substantial, of abundant size to accommodate the heavy screens, and to leave room for the workmen. The structure is very carefully braced, and hardly any tremor is noticeable at any part of it, even when the apparatus is running at full speed. The portion of the tipple supporting the screens is also strengthened and stiffened by an independent set of braces similar to the main engine braces, which run down to independent foundations near the shaft.

Another special feature of this plant is the wide shed on either side of the tipple, covering all four railroad tracks. These sheds, together with the width of the tipple, give a total length on the tracks of 77 ft., enabling the car trimmers to work under cover at all times. The screening and weighing plant makes it possible to obtain perfect sizing and to load the coal into the cars with the least possible breakage, so that having so mined the coal as to secure the highest possible percentage of large sizes, it may be possible to bring the product to the market without nullifying this advantage. On account of the extraordinary size of the pit cars, it was necessary to have a very large weigh hopper, and the method of operating the weigh hopper door can readily handle this large quantity of coal. There is a double chute just below the self-dumping cages, into which the cars from both compartments of the shaft are dumped. This chute tapers from a width of 17 ft. at the top to about 15 ft. at the bottom. This weigh hopper will hold at least three pit cars of coal or a maximum of 12 tons. This chute is on a scale frame and the scale beam for it is in the weigh house just above the weigh hopper. The door to this hopper is opened by a steam jack, which can be operated slowly to discharge this large quantity of coal very gradually onto the screens. These screens are 56 ft. by 9 ft. in size, made in two sections and hung from the structural

steel above. They are operated by a pair of direct acting, 10x16 engines. The chutes beneath these screens are arranged to permit almost any combination of the four divisions of coal. There are also hoppers just above each car, of sufficient size to hold two or three pit carloads of coal. This enables the screens to be operated continuously while cars are being changed. There is also a special raising and lowering chute at the lower end of the screens to accommodate the discharge to high or low cars, thus avoiding breakage. There is also a device for holding the coal in this chute while the car on this track is being changed. The screens are covered throughout with 3/16-inch steel plates, which can be raised or lowered as desired to permit any combination of sizes required by the market. The normal divisions arranged on the screens are 7/8-inch or 1¼-inch screenings on the first track, 2-inch or 2½-inch nut on the second, 4-inch or 5-inch as desired on the third track, and 4-inch to 5-inch screen lump on the outside or lump track.

This plant is giving excellent satisfaction throughout, and it is hoped that the mine will be near the top of the list of producers before the close of the present year. The mine began to ship coal early last year, and has a capacity at present of about 1,200 tons per day. About 500 employes are on the mine pay roll. The company's mines are on the tracks of the St. Louis & O'Fallon Railway Co., which is owned and operated by the St. Louis & O'Fallon Coal Co. This road carries the company's product to East St. Louis, connecting with the St. Louis Terminal Railway system. It consists of about 10 miles of main track and 5 miles of sidings. The equipment is first class in every respect, including 85 pound steel rails, several 64-ton locomotives and 500 new steel coal cars with a capacity of 100,000 pounds each.

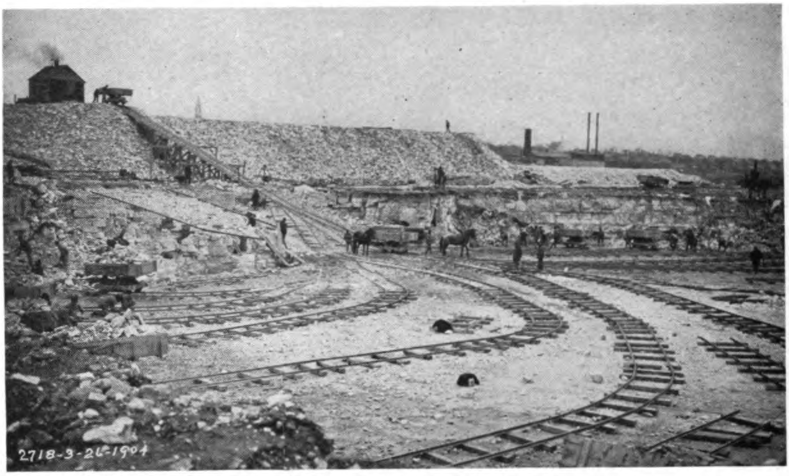
We are indebted to the courtesy of Mr. James M. Browning, President of the company, for the information and photographs used in the above article.



Sullivan Class "C" Drill, on an angle hole 1600 feet deep, Kalgoorlie, West Australia

DIAMOND DRILLING.

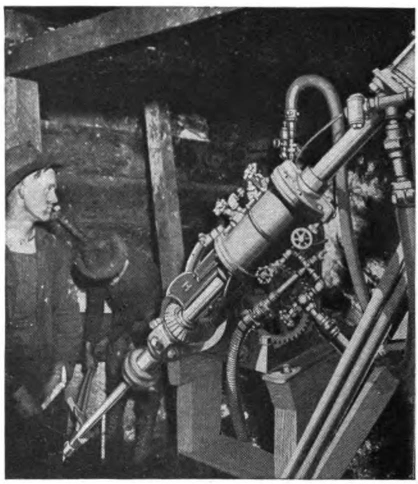
"The usefulness of the diamond drill in mining is recognized by the three companies operating on a large scale in the Boundary," says the Victoria, B. C., correspondent of the Engineering and Mining Journal. "To date, the Granby Company has drilled holes totaling



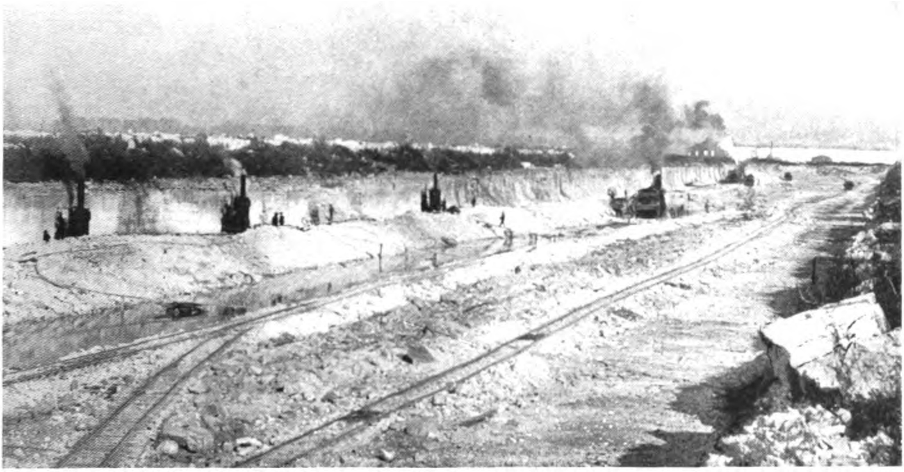
Rock Excavation on Upper Headrace, Chicago Drainage Canal

between 17,000 and 18,000 feet for the purpose of determining the extent of known ore bodies and prospecting new ground. The B. C. Copper Company, during the last twelve months, has drilled between 3,000 and 4,000 feet in its Mother Lode mine, and recently commenced using the drill in the Emma mine, also in this district. The Dominion Copper Company is preparing to put in a number of drill-holes from the lower levels of its Brooklyn mine at Phoenix. Drills have also been used for prospecting purposes in the Oro Denoro, the Betts and Hesperus mines."

Diamond drill work in the Transvaal at great depths, continues active. A bore-hole sunk at an angle of 45 degrees from the foot of the Cinderella shaft, near Johannesburg, encountered the Main Reef at a vertical depth at 3,980 feet from the surface. Six feet of the quartz core assayed 20.56 dwt. per ton, with 92.78 dwt. in the 15 inches next the foot wall. The deepest bore-hole on the Rand reached ore at 5,582 feet; this depth, however, will soon be surpassed, if the present



Sullivan "H" (1,000 foot) Drill, in Calumet & Arizona Mine



Sullivan Channelers and Steam Shovel on Upper Portion of Tailrace

plans of some of the companies are executed. The Sullivan "P" and "K" drills, with single cylinder hydraulic feed, are used for work of this description.

THE POWER EXTENSION OF THE CHICAGO DRAINAGE CANAL.

At the present time the Chicago Drainage Canal ends at the Northern limits of Lockport, 28 miles from Chicago. The water passes over a bear trap dam at that point into the bed of the Des Plaines river, which has been widened here to care for the increased volume and speed of the current. The portion of the canal now under construction extends through Lockport to the northern limits of Joliet, some four miles below.

The object of this extension is twofold; (1) to develop hydro-electric power by taking advantage of the fall in the Des Plaines Valley at this point; this power will be transmitted to Chicago by high tension lines for use by that municipality and others in the district. (2) To provide another link in the deep waterway from Lake Michigan to the Mississippi river. The recent decision of the Supreme Court of the United States, in denying the contention of the State of Missouri that Chicago should not divert its sewage into the Illinois river, enables the Sanitary District to proceed with its plans without fear of future hindrance. The power to be developed is 40,000 horse power at the dynamo, based upon a head of 34 feet and a flow of 600,000 cubic feet per minute. In order to secure this volume, the South branch of the Chicago river is now being widened to

200 feet. The grade of the canal is one foot in 20,000.

A canal boat lock is provided for, 46 feet in width, by 136 in length, at the power house, to handle the traffic now carried on the old Illinois and Michigan Canal, and an 80 by 600 foot ship canal lock is also planned, to be built when arrangements for the waterway to the Mississippi are completed. A bear trap dam will regulate the flow of water. The general arrangement of these projects is shown in the drawing on page 14.

The present extension is divided into three sections (a) the headrace, 10,700 feet long, with minimum depth of 22 feet and 160 feet in width; (b) the power house, 386x 159 feet in size, and two stories high; (c) the tailrace, 6,800 feet long and of the same width and depth as the headrace.

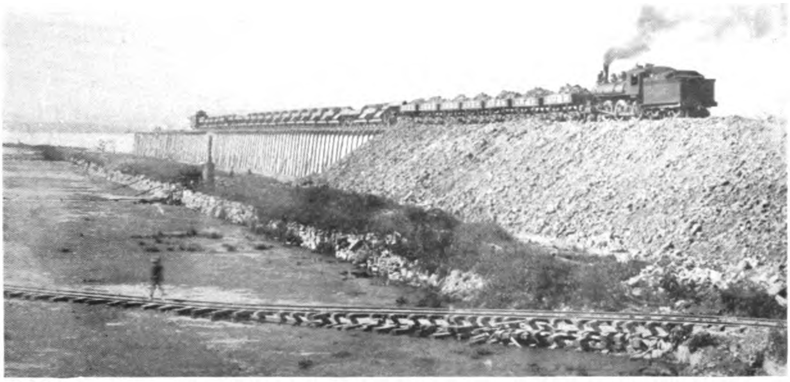
The entire work comprises 105,000 yards of earth removal, 1,273,540 cubic yards of rock excavation, 366,-484 cubic yards of earth embankments, 977,084 cubic yards of rock embankment and 150,000 yards of concrete.

Work was begun early in 1904, and the developments described in the present article will be completed late this year. Owing to the delay and cost of condemnation proceedings, the widening of the Chicago river may not be finished at this time. The present flow of water will generate 20,000 horse power at the dynamo. The canal boat lock and the new bear trap dam are but just begun, contracts for the work having only recently been let.

HEADRACE.

The headrace is excavated entirely through rock, the spoil being used to form a heavy earth and masonry embankment or levee upon the right side of the channel, and a concrete wall supported by rock fill, upon the left side. The cut on page 10 shows the character of the work.

The engineer's specifications provided that the rock walls of the channel should be cut true to line before any of the material within was blasted or removed. This work was accomplished by the use of four standard Sullivan class "Y" stone channeling machines, of the rigid head type, with boilers. These channelers make a vertical rock wall cut from 9 to 12 feet in depth, and are similar to those used in 1893-4-5, on the main canal. A solid Z shaped bit was used, instead of the five-piece gang bit customary in quarry service, in order to avoid the danger of sticking in the seamy Joliet limestone. By adopting this method of outlining the canal the engineers secure a smooth wall, unshattered by explosions, which will remain firm and impervious to weather as long as the work is in use. As the walls are true and accurate, no extra trimming or filling was required to bring them to line, as would have been the case if blasting had been adopted. The accompanying photograph



Filling In the Embankment on Both Sides of the Core.

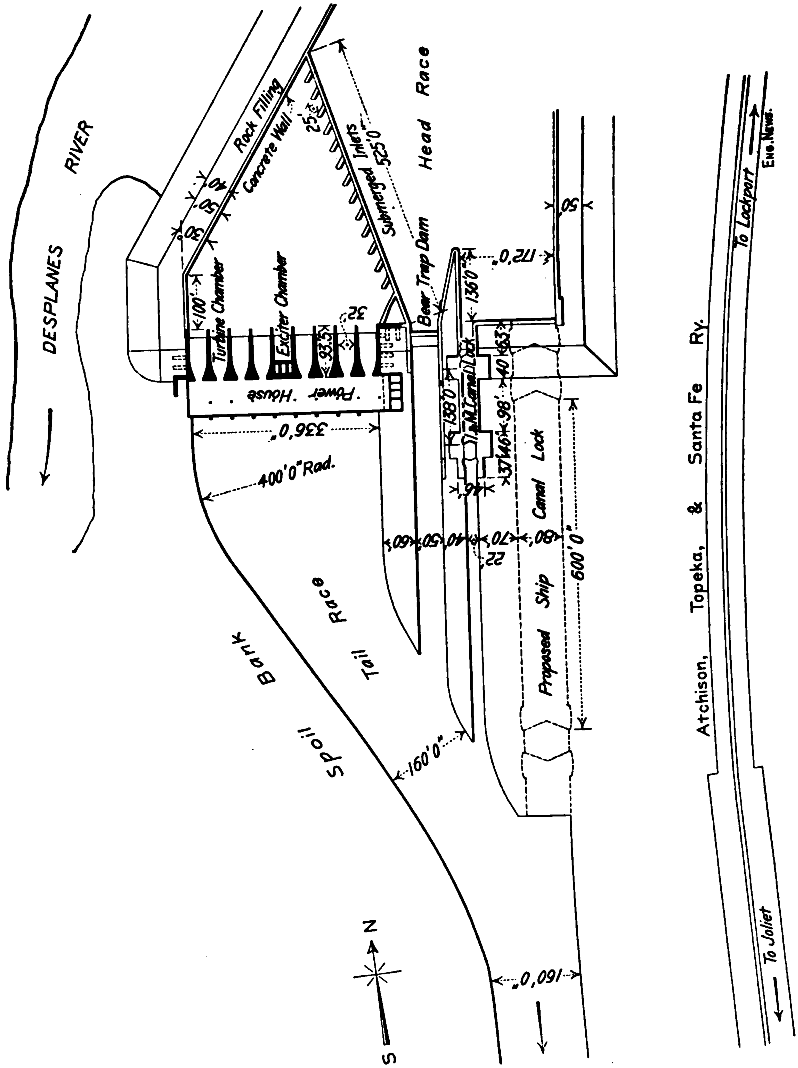
(page 11) shows three of these machines at work in the tailrace, just below the power house, cutting the second "lift" of the west or right hand wall of the canal. The channelers ran under their own steam, at 100 to 120 lbs. pressure, although for a portion of the time they were supplied by air at 80 lbs. pressure, from the central air compressor plant on the work.

The channelers were followed by rock drills and steam shovels, which removed the materials within the rock walls by blasting and loading into dump cars. Small steam locomotives hauled the cars to inclined cableways by which they were carried to trestles along the margin of the canal and dumped, forming high banks.

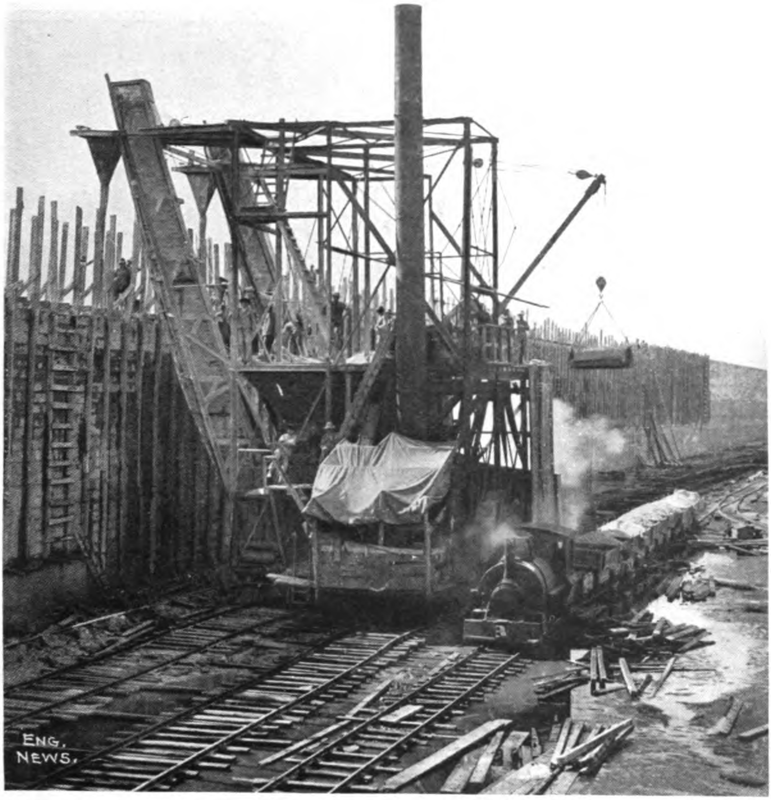
Rock crushing plants were then installed at several points on the work, and the broken material served to concrete mixers which produced the concrete used in the core of the embankment on the right side of the canal, and in the retaining wall on the left side.

CONSTRUCTION OF CONCRETE WALLS.

The core wall for the right hand embankment of the head race was built before practically any of the earth filling on each side of it had been made. (See page 13). It is built monolithically, the concrete in it being laid continuously by day and night shifts. The high retaining wall on the opposite side is built with expansion joints. The wall is built in alternate sections, generally 100 feet long, and the ends of the sections keyed together. A considerable portion of the fill, back of this wall, was made before construction had been started on the latter. Part of the embankment was made with material from the headrace



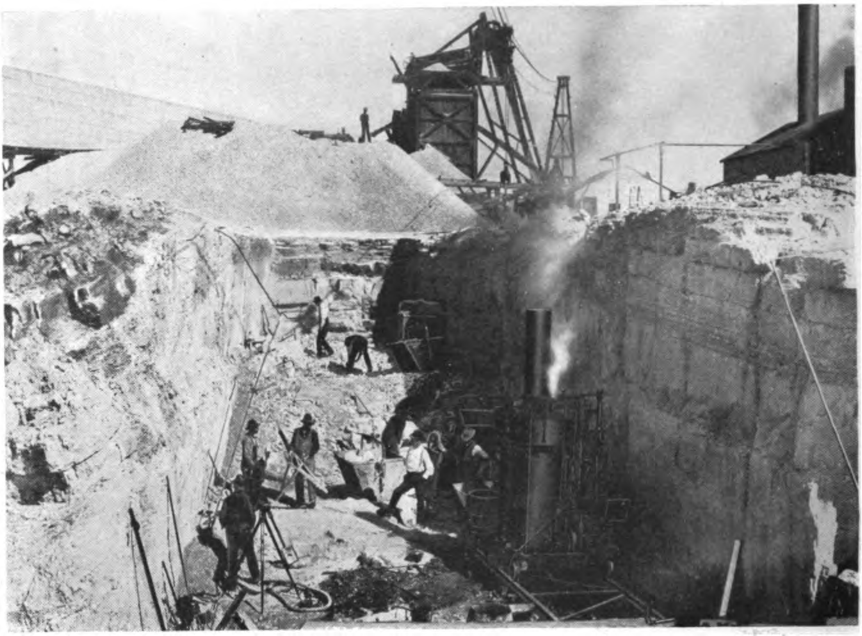
Turning basin, dam, locks and plan of power house. From a drawing furnished by the Sanitary District



One of the Concrete Mixing and Elevating Machines used in Building the Retaining Wall

channel by the typical excavation methods employed on that work, and was kept well back of the line of the rear face of the wall. As the latter is completed the embankment is brought to grade between the part built first and the wall, from trestles, with material hauled from the tailrace. This wall is 6 ft. thick on top and 16 ft. at the bottom, and varies from 25 to 38 ft. in height.

Two large movable plants for mixing and elevating the concrete to position were built by the contractor, as illustrated in the accompanying photograph. These plants are each built upon two flat cars placed side by side. A 100 horse power boiler and engine are mounted on these cars and transmit power for moving the cars along the track and for the concrete mixers, hoisting derricks, etc., by means of a line shaft and



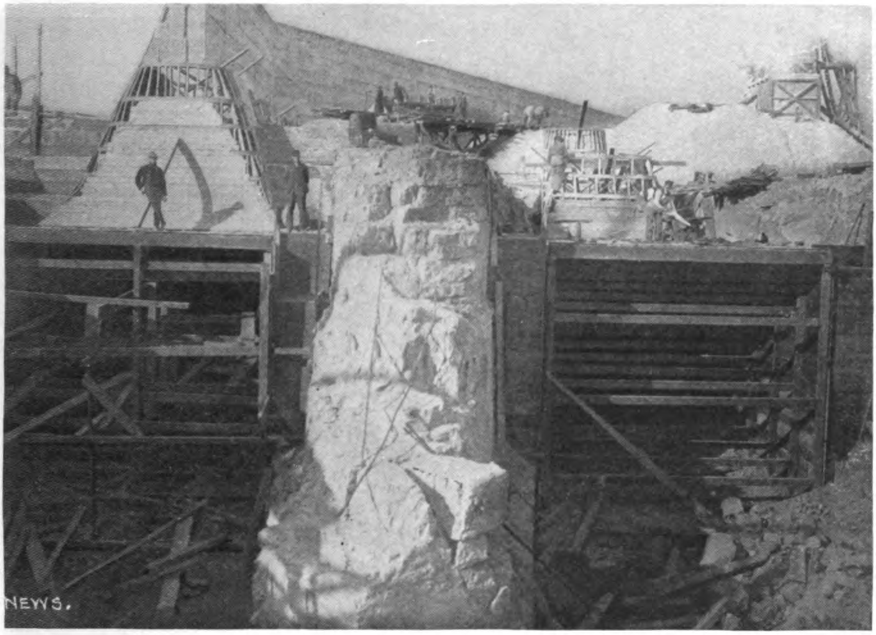
The Sullivan Channeler excavating one of the Turbine Wheel Pits

friction clutches. There are three floors or stories; the top floor receives the broken stone, screenings and cement. The latter two materials are dumped into hoppers leading to a dry concrete mixer on the first floor, on the car next the wall, the outer car being occupied by the boiler and engines. Thence the mixture passes by bucket elevators to two wet mixers, on the second floor, where it is combined with the broken stone and is thence carried to place in the wall by inclined bucket elevators. These two plants mixed and placed 100,000 cubic yards of concrete during the last season, or an average of 300 yards each per 10-hour shift.

POWER HOUSE.

The arrangement of the power house, forebay, turning basin, dam and locks, is shown by the accompanying drawing, page 14. The concrete wall running diagonally across the basin from the outer end of the dam forms the head bay, and has submerged openings or inlets, the intrados of the arches being 12 feet below Chicago datum (low water level of Lake Michigan of 1847). This will protect the water wheels from floating ice and drift, which will be discharged over the bear-trap dam.

There are eight wheel pits and one exciter pit, divided into three compartments. The wheel pits are 115 feet in length, and range in width

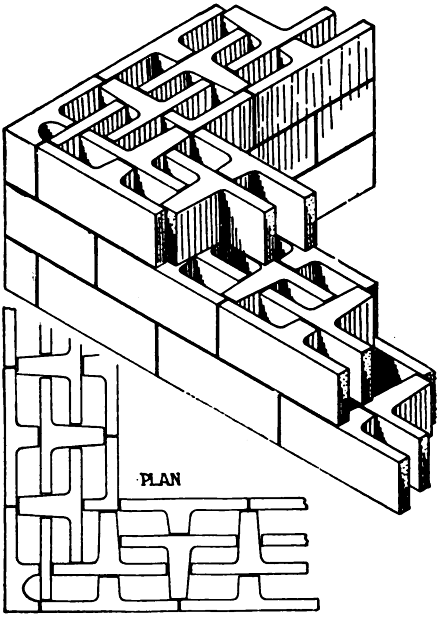


Two of the Pits, with False Work for Walls and Turbines

from 7½ feet at the headrace end to 32 feet at the other; they are 28 feet deep at the lower end. Each pit has four draft tubes for the six wheels mounted on one shaft, and the tubes discharge into the arched openings of the tail pits, passing under the power house to the tail-race. Across the entrance to each pit are the racks to exclude any ice or drift that may pass through the submerged openings, and behind these are folding gates, which can be closed to shut off the water and allow access to the wheels. Any water leaking through these doors is taken care of by a 16-inch cast iron drain pipe imbedded in the concrete and discharging into the first draft tube. The work was designed by Albert S. Crane, Hydraulic Engineer.

CONSTRUCTION WORK.

The excavations for the wheel pits and for the foundations of the dam and power house are in the Joliet limestone. This is fairly solid, but contains a number of springs which required special attention, and also developed some deep clay pockets running (as on other parts of the canal) from southwest to northeast. The pockets are from 2 feet to 10 feet wide and consist of a stiff blue shaly clay, which gradually softens when exposed to air and water. In order to prevent the possible blowing out of the clay under the walls



Two Piece Concrete Block Construction

in the future, when softened by long exposure, concrete cut-off walls are carried down 15 or 20 feet into the clay, and where the surface of the clay is exposed it is excavated and covered with a floor of concrete.

The power house is formed as an integral part of the dam and has concrete foundations on the solid rock. The wheel pits are also excavated in the rock and were outlined by a Sullivan channeling machine before any blasting was done, so as not to disturb the rock of the piers or abutments between the pits.

A careful record was kept of the square feet channeled by the machine used on the wheel pit excavations. The best record made at one time was 382 feet in 12 hours. The total cutting in 40 consecutive shifts of 10 hours each during June, 1905, was 8,120 feet or 203 feet per shift. The machine frequently worked 24 hours a day and seven days a week, but was run continuously through the entire summer and fall without repairs. In comparison with these records it may be interesting to note the performance of 15 of the 55 Sullivan channelers used in the construction of the main channel of the Chicago Drainage Canal, as indicating the improvement that has been made in the manufacture of these machines in the last 12 years. During May, 1895, on that work the 15 machines referred to, averaged 116.2 feet each per shift, as compared with the record of 203 feet per machine per shift on the present work. The construction conditions on both pieces of work were practically the same, and in all cases delays of all kinds are taken into account.

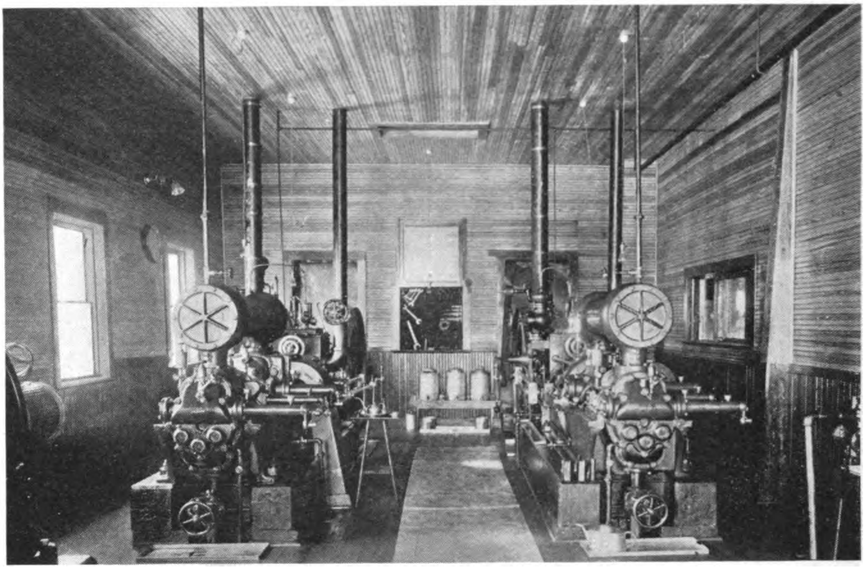
The pits are all faced with concrete about 36 in. thick, worked with spades to give a smooth surface finish. The dump cars, filled by a steam shovel in the bottom of the excavation, were hauled out on a cable incline at one side and taken in trains to the dumps behind the retaining walls or to the crushing plants for the concrete work on these walls. The stone for the concrete of the power house was loaded into the bucket of a cableway 400 ft. long, and delivered either directly to the stone bin, or to cars running to this bin. This cableway was placed

The Coffer Dam, Lower Tail Race

parallel with the line of the canal, and was moved laterally to serve the work at the different pits. Steam for the channeler, drills, hoist, cableway and concrete mixer was generated at a central boiler house, containing two boilers of 100 horse power capacity each, and distributed by pipes, the greatest distance from boiler to work being about 400 feet. The cut on page 16 shows the channeler in the bottom of the pit, and the cableway above it with the crusher and stone pile in the background and the concrete retaining wall of the forebay at the left. The cut on page 17 shows two of the pits, with the forms for the concrete lining and also the forms for the draft-tube opening.

POWER HOUSE OF CONCRETE BLOCKS.

This building is notable in that concrete block construction was adopted for both plain and ornamental work. As already noted, the power house and dam form practically one structure. The north wall, which is the dam proper, is of concrete; the south and end walls will be of concrete blocks. The roof will have steel trusses, with plank sheathing covered with asphaltum felt, and red tile. The walls, built of blocks, are 37 in. thick at the base and at pilasters and 28 in. at the top and between pilasters, and are composed of T-shaped blocks, illustrated on page 18. The ordinary blocks are machine molded, but the blocks for the ornamental work, cornice, reveals, etc., the voussoirs for the window arches, and the large blocks for lintels, sills, pilasters etc., are tamped by hand. The large blocks are also reinforced by plain round steel rods. The color is a light gray and the face is of a close and even texture. A



Sullivan Straight Line Air Compressors at the Golden Cycle Mine, Independence, Colorado (See page 23)

water proofing mixture is used to face the blocks forming the exterior walls.

A 50-ton electric traveling crane will provide for the handling of heavy machinery in the power house.

TURBINES AND GENERATORS.

The power house is arranged for eight units in two groups of four, separated by three exciter units. The present contract, however, is for four power units and two exciter units. Each of the 6,500 horse power units will have six wheels, mounted on a 12-inch horizontal shaft, the shaft projecting through stuffing boxes in a steel bulkhead wall into the generator room and being coupled to the shaft of a revolving field, 60-cycle, three-phase generator. The normal head, as measured between the level of water in the turbine chamber and the tail race when all the wheels are running, is 34 ft. but under operating conditions the head may vary from 30 to 38 ft. The turbines are of the Jolly-McCormick type, and the contract also includes two 600 horse power turbines for the exciters, with Lombard water wheel governors and the necessary gate opening mechanism. The specifications required for each power unit a discharge of 100,000 cubic feet per minute, with 0.8 gate opening, the power not to be less than 5,000 horse power at such opening and the speed not less than 165 revolutions. The efficiency of the turbines must be at least 80 per cent. from 0.75 to full gate when running

at the required speeds, the same speed being maintained from 0.75 to full-gate.

The four generators will be of the revolving field type, 4,000 K. W., 60 cycles, three-phase, 6,600 volts, and running at 165 revolutions per minute. Each of the two exciters will be a 350 K. W., 250-volt, multipolar, direct-current, compound-wound generator, running at 300 revolutions per minute and having a shaft with two self-aligning and self-oiling bearings.

TRANSMISSION LINE.

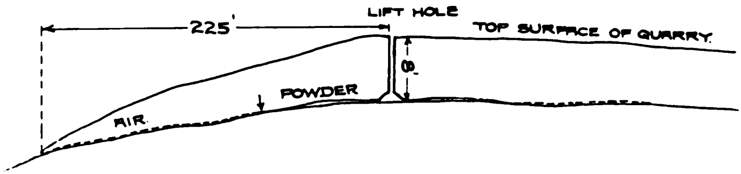
The length of the high-tension transmission line to Chicago will be about 30 miles, and it will be built on a private right of way from 200 ft. to 1/4 mile in width. The poles will be spaced about 300 ft. apart, and will have two cross-arms, 18 ft. 6 in. and 12 ft. long, with Locke three-part insulators. There will be four wires on the lower arm and two on the upper arm, the bottom wires being 47 ft. above the ground. There will be two circuits, and aluminum wires are to be used, equivalent to copper of No .000 gauge. The current will be generated at 6,600 volts at the power house, stepped up to 44,000 volts for transmission, and delivered from the Chicago sub-station at 6,600 to 9,000 or 11,000 volts. Mr. E. B. Ellicott is electrical engineer.

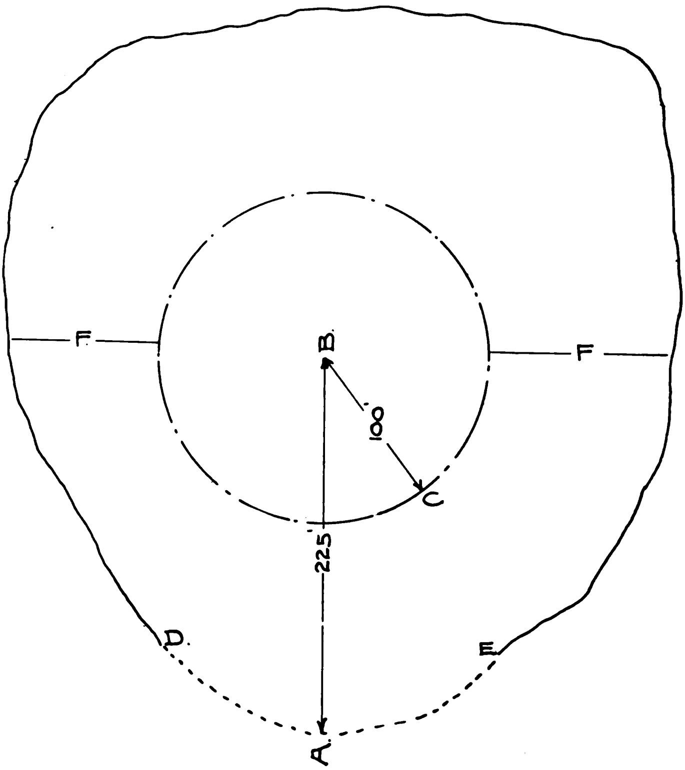
TAILRACE.

The tailrace was excavated partly in rock, by the use of channelers and drills, as above described in connection with the headrace. (See page 10). The lower portion, however, runs in the bed of the Des Plaines river, which is 400 ft. wide at this point. A coffer dam nearly one mile in length was erected, laying about one-half of the river bed bare. The bed was then excavated 160 ft. wide and ranging in depth from five ft. at the upper end to seven at the lower. Two or three feet of earth was first removed, the remainder, in solid rock, being excavated by rock drills and steam shovels. Difficulties were presented by the constant leaking of the cofferdam, due to the irregularity of the bottom of the river, caused by the original improvements at this point, of the Sanitary District.

The contractors for the head race and for that portion of the tail race requiring channeling are J. J. Duffy & Co., of Chicago. Lorimer and Gallagher, of Chicago hold the contract for the remainder of the tail race, and Hayes Bros. Co., of Janesville, Wisconsin, are constructing the power house.

Mr. Isham Randolph, member American Society Civil Engineers, is chief engineer in charge of the work. We are indebted to Mr. Geo. M. Wisner, assistant chief engineer, for drawings and information, also to Mr. Edward L. Lahey, inspecting engineer on the power house section, and to the contractors on this portion of the work for photographs. Articles regarding the details of this work have appeared in the Engineer-





KEY—

B—Lift or Drill Hole.

BC—Area Cleaved by Powder.

AFF—Area Cleaved by Compressed Air.

DE—Thin Edge on down hill side of quarry, where air escaped.

ing News of January 12th, 1905, January 18th, 1906, and the Engineering Record of February 17, 1906, from which we have quoted to some extent in the present article.

LOW COST OF COMPRESSING AIR FOR DRILLS.

(From the Cripple Creek Daily Times)

An interesting feature of mining in the Cripple Creek district, and an item which is as closely watched by the operator as any other, is the cost of making air per drill shift, upon which largely depends the possibilities of economical operation. The wide range in this one respect is shown by the fact that in some instances the cost is as high as $3 per drill shift, while in others the same results are obtained at a cost of 53 cents. This great difference is due to the class of machinery used and the care and intelligence with which it is operated. Of the different records obtained from mine operators the following seems to show the greatest economy:

Mr. John Sharp, the well known lessee who is operating the Morning Glory of the Work and the Colorado Boss of the Cripple Creek Consolidated company furnished data covering a period from September 20, 1904, to January 17, 1905, during which time 1,367 drill shifts were operated. As shown by his books, during that time, the coal bills amounted to $1,183.17. The greatest number of shifts worked in one month was in October, when 492 were employed.

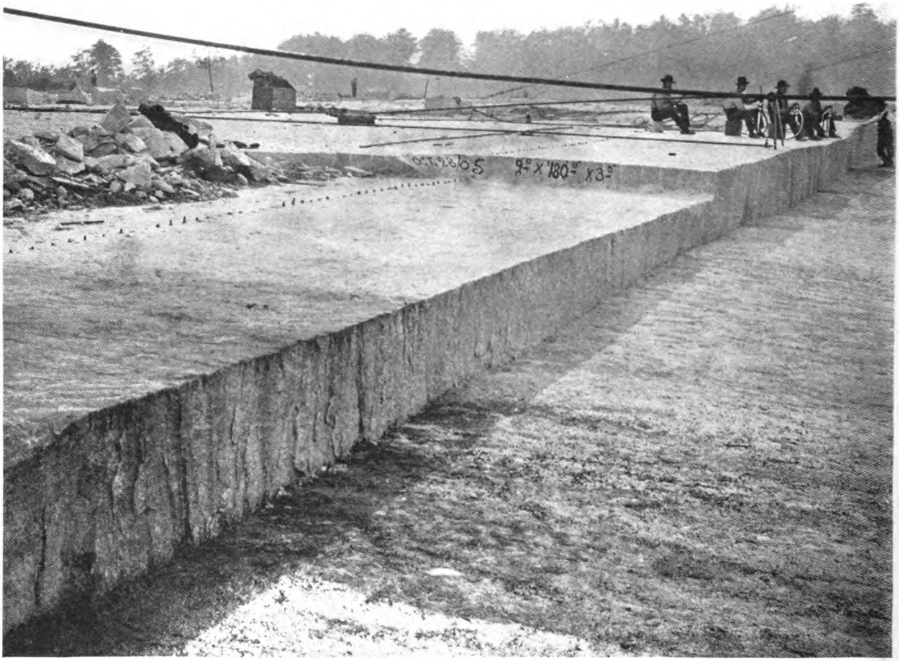
The rock hoisted amounted to 7,500 tons during the months of October, November and December, and the coal bills for hoisting amounted to $450, leaving the total coal bill for running the air compressor $733.17 or 53.7 cents per drill shift.

It is doubted if this record can be duplicated in the district. In speaking of his accomplishment in economical operation Mr. Sharp said: "I think that my record for making air per drill shift is about as low as it can be made. My cost was 53.7 cents per drill shift for coal. The machine used was a straight-line compressor with simple steam and compound air cylinders, and was built by the Sullivan Machinery company of Chicago. It is supposed to operate only ten drills, but often exceeded the rated capacity. In my opinion it is as economical a compressor as can be constructed and certainly the tests I gave the machine under all conditions, are sufficient to demonstrate this fact."

CLEAVING GRANITE BY COMPRESSED AIR.

Necessity is the mother of invention in the stone quarrying business as in other branches of human activity, and the inventions and circumventions of quarrymen are many and varied. One of these, which we believe has not come to general notice, is the use of compressed air for splitting granite, to create working beds as practised by the North Carolina Granite Corporation, at Mt. Airy, N. C.

The company's property covers a gently sloping hill-side of many acres, consisting of a perfectly solid, homogeneous mass of moderately hard granite. This stone shows no ledges or bed planes whatever, but splits readily in a straight line in almost any direction. In order to make quarrying economical, this feature is taken advantage of to create

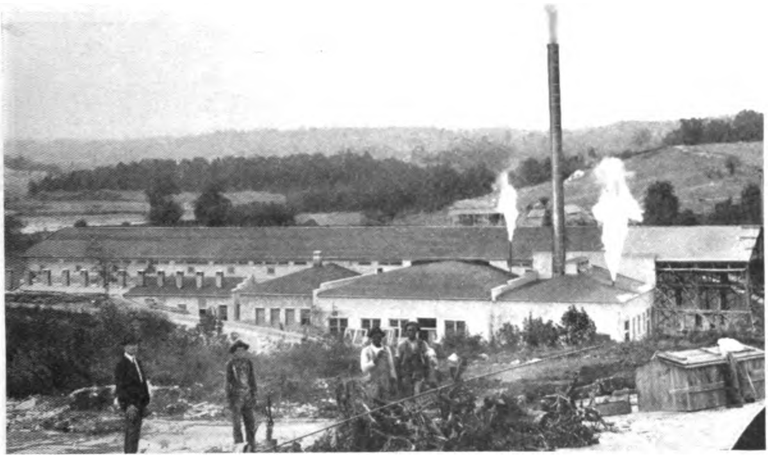


A Corner in the North Carolina Granite Corporation's Quarry

artificial beds to which to work. Large sheets or laminations of granite are separated from the mass at a single operation in like manner as an onion is peeled, by the successive use of powder and compressed air. The stone is then split up into proper sizes for building stone, paving blocks, curbing, lintels, and stock for monumental purposes, at very low cost.

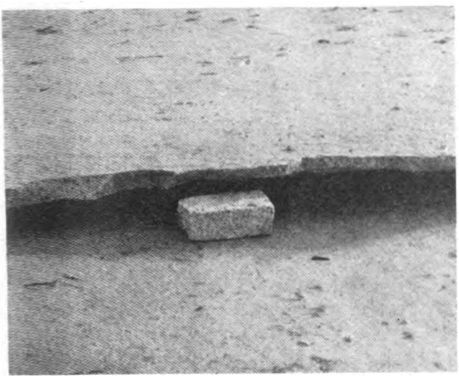
In the center of the sheet or area to be lifted, a drill hole two or three inches in diameter is sunk six or eight feet in depth, depending on the greatest thickness of stone required. The bottom of the hole is enlarged into a pocket by exploding half a stick of dynamite, as indicated in the sectional sketch shown on page 22. A small charge of powder, about a handful, is then exploded in the pocket, thus starting a horizontal crack or cleavage across its greater diameter. Charges increasing in size are now exploded in the cavity, the drill hole being plugged at each blast, to confine the powder gases and thus exert a more or less constant force upon the stone.

After the cleavage has extended to a radius of 75 or 100 feet in all directions from the lift hole, a pipe is cemented into the hole and connected by means of a globe valve, to the air pipe line from an air compressor. Compressed air at 70 to 80 pounds pressure is gradually ad-



Power House, Cutting Sheds and Offices

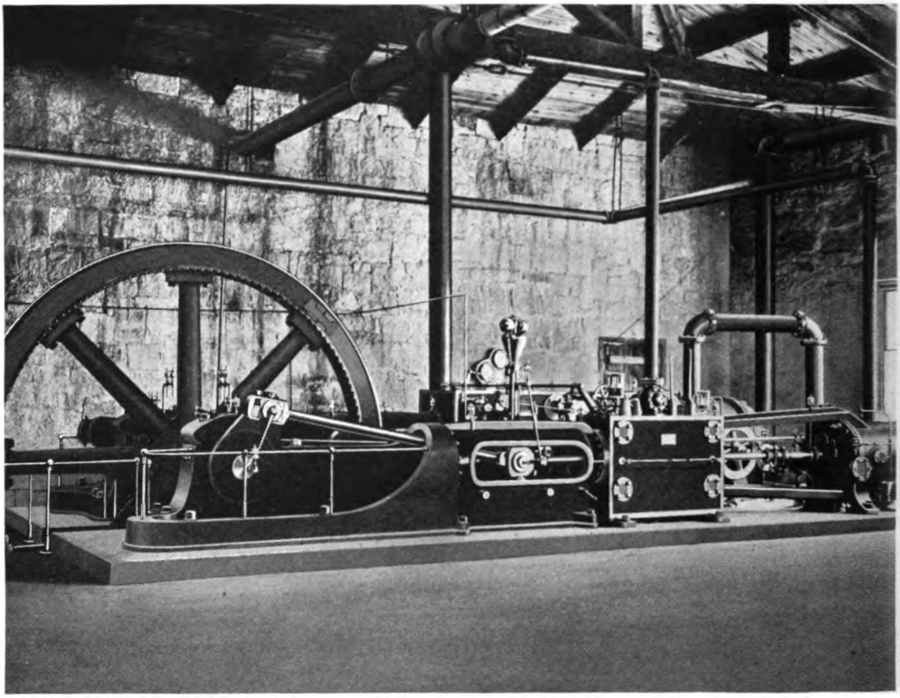
mitted and the cleavage rapidly extended until it comes out upon the hillside in a thin edge, as indicated by the cross sectional sketch referred to above. A sheet of several acres in extent may be raised in this manner, affording a bed plane approximately horizontal, to which the quarrymen can work, thus securing stone of any required thickness.



Thin edge of sheet split from quarry

This method was not perfected in a day, but represents a gradual development. For a number of years, the company has followed the practice of quarries in the Lithonia and Stone Mountain districts of Georgia, in splitting ledges in the above manner by the use of powder alone. This system, however, was not entirely satisfactory, as the amount of powder used was necessarily considerable, and the time required for raising such a large area of granite was quite long, as unless considerable care is taken and time afforded for the stone to split gradually with the aid of natural expansion and contraction, the force of the explosion brings the cleavage abruptly to the surface.

Some time ago the North Carolina Granite Corporation substituted water under pressure for powder, after the cleavage had extended some little distance from the drill hole. This was found to be an improvement, but was surpassed in economy and convenience by compressed air when the company installed a new Sullivan air compress-

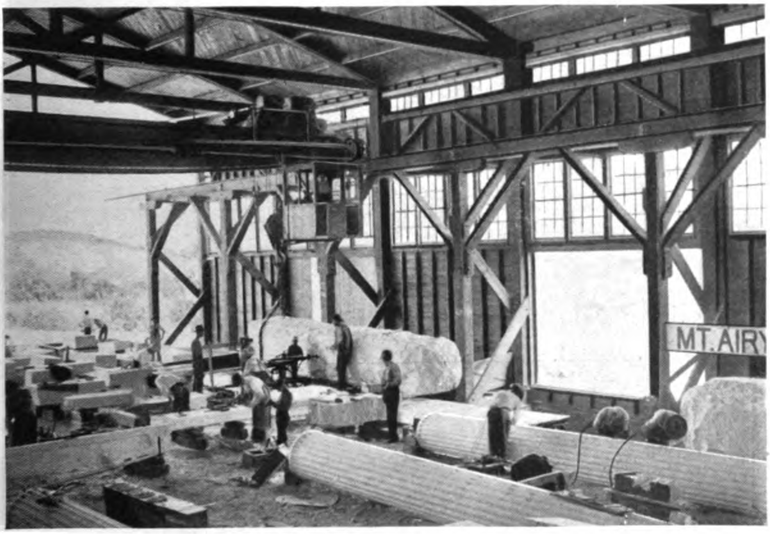


The Sullivan Corliss Two Stage Air Compressor

or, especially built for this plant, last season.

When the compressed air was first tried, a pressure of 80 pounds was admitted into the cavity, which had previously been extended to a distance of 100 feet from the lift hole. The power of the air was too great for the easily splitting stone, and the cleavage turned abruptly to the surface. A new drill hole was sunk in another part of the quarry, and the cleavage extended by powder in the same manner as before. The compressed air pipe was then attached once more and air admitted very gradually. The stone could soon be heard cracking in all directions, and in about half an hour the cleavage came to the surface in a thin edge on the hillside, some 225 feet from the lift hole. (See cut on page 25). The time required for extending the cleavage by powder for 100 feet was between two and three weeks, while to split the larger area, between 100 and 225 feet radius, required only half an hour when compressed air was used.

The accompanying sketch (page 22), shows how the area, covering nearly 2½ acres, was raised by this means. Only a portion of the cleavage extended to the surface, owing to the thickness of the ledge on the up-hill portion of the area. The bed plane thus formed was reached at these points by quarry bars and drills in the usual manner. So far



Interior of Cutting Shed

as known this is the only quarry in which compressed air is used to split granite in this manner, and it can readily be understood that this process accomplishes a great saving of time and expense.

The North Carolina Granite Corporation is enabled by this and other economical methods of operation, to produce granite for many building and paving purposes at a price comparing favorably with any quarry in the country. Its equipment is modern in every respect, and includes 35 plug drills, three Sullivan tripod drills, four Sullivan quarry bars, 15 surfacing machines and 60 small hand tools. These are all operated by air power from a Sullivan Corliss air compressor, furnished by the Sullivan Machinery Co., of Chicago. (See page 26). This compressor is of the two stage type, with a piston displacement of 2,000 cubic feet of free air per minute at 78 r. p. m., against 80 to 100 pounds terminal pressure.

The dimensions of this compressor are as follows: steam cylinders, 16 and 28 in. by 42 in. stroke; air cylinders, 26 and 16 in. by 42 in. stroke.

The steam end is a Sullivan heavy duty Corliss cross-compound condensing engine, to the rear of which the air cylinders are coupled in tandem. All cylinders, both steam and air, are made with separate liners, forced into the cylinder castings by hydraulic pressure. A steam receiver and reheater is situated between the high and low pressure steam cylinders, below the floor line. Air efficiency in this machine is rendered unusually high by the valve motion employed, which consists of Corliss inlet valves upon both air cylinders, and automatic poppet discharge valves situated in the cylinder heads. These valves, together with their seats, are readily removable for inspection or regrinding. The air supply is drawn from outside the engine room, thus insuring cold, clean dry air, and the

air cylinders and cylinder heads are water jacketed. The heat of compression is further removed by a large receiver intercooler between the high and low pressure air cylinders.

The general view of the quarry, (page 24) shows one of the nine cableways by which the stock is handled between the quarry and the cutting shed and cars. There is also an incline for loading rough stock for shipment. The engine room, offices and cutting and finishing sheds are of modern design. The boiler and engine house is 112x53 feet and contains two 210 H. P. water tube boilers, a 150 H. P. Ideal compound engine coupled direct to a 100 k. w. generator, and the air compressor above described. The cutting shed is 360x65 feet in size. Stock is handled by a 20-ton Pawling & Harnischfeger electric crane, with a 5-ton auxiliary hoist.

The company has made ample provision for further enlargement of its equipment, to care for its rapidly growing business.

MINE AND QUARRY is indebted to Mr. Thomas Woodroffe, vice president of the company, for photographs and information used in this article.

SUGGESTIONS FOR OPERATION OF ROCK DRILLS.

When drilling in sandstone the drill-bit should be tapered somewhat and then flattened instead of drawn to a cutting edge. If a chisel-bit is used in drilling sandstone, the bit will wear very sharp, and will frequently become fitchered.

In forging rock-drill bits, those for medium hard rock should have sharp chisel bits. As the hardness of the rock increases, the angle of the bit may be made more blunt, and the cutting edge shaped from a straight line to a curve, to prevent the corners being chipped off.

Never rush a missed hole—give it plenty of time, and all night is not too long sometimes. The missed hole is one of the greatest menaces to the miner. When safe to examine the hole, carefully withdraw the tamping down to the powder, insert another primer, and after retamping the hole, fire it again. Should it go, the chances are in favor of all the powder in the hole being exploded.

—From the Mining and Scientific Press.

A rock drill pipe line which has been choked by freezing, may be cleared almost instantly by turning a very small amount of wood alcohol into the line. It will hardly prevent frost from reforming, except for a short time, but is of great aid in cleaning out frost already formed.

Cutting of rock drill cylinders is often due to lack of proper lubrication. When a new drill is started up, a lubricant consisting of one pint of cylinder oil to one-fourth pound of flake graphite should be used, one tablespoonful of lubricant for each five-foot hole drilled, during the first ten or twelve shifts. After this, use a good grade of drill oil, one spoonful for each ten-foot hole drilled.

MINE AND QUARRY

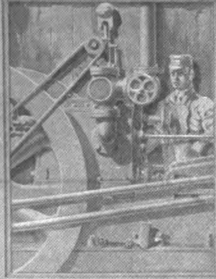
I. NO. 3. NOVEMBER, 1906

MINING "BLACK DIAMONDS" IN BAHIA, BRAZIL.

"Black Diamonds."

Quarrying Marble in Georgia.

The Tidewater Railway, Construction Progress.



PUBLISHED BY THE SULLIVAN MACHINERY CO. RAILWAY EXCHANGE BUILDING, CHICAGO.

TABLE OF CONTENTS.

	Page
Editorial	57
Quarrying Marble in Georgia	58
"Black Diamonds," Their Origin, Production and Use	64
Construction Progress on the Tidewater Railway	70
A Southern Ohio Freestone Quarry	75
Methods Used to Reduce the Cost of Drilling at the Wabana Iron Mines, and Cost of Drill Repairs	76
Machine vs. Hand Mining	79
Care of Discharge Valves for Sullivan Air Compressors	84

MINE AND QUARRY

Vol. 1. No. 3. NOVEMBER, 1906.

A Quarterly Bulletin of News for Superintendents, Managers, Engineers and Contractors.

Published by the Advertising Department of the Sullivan Machinery Company.

Address all Communications to MINE AND QUARRY, Railway Exchange, Chicago. Sent to any address upon request.

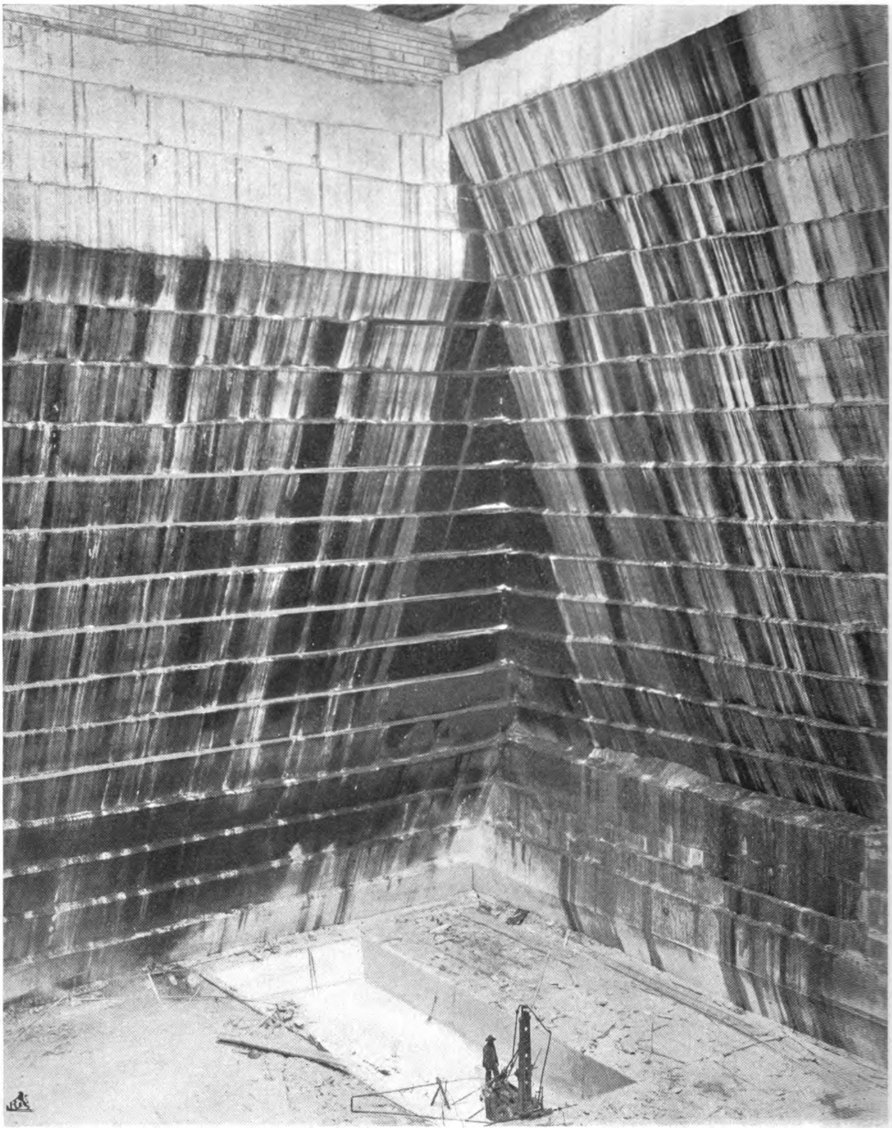
Readers are requested to notify MINE AND QUARRY of any correction or change in address.

There are still a few copies left of the May and August numbers of MINE AND QUARRY, which are reserved for those who wish to complete their files.

A German mining engineer, now visiting this country, remarks on the absence of American technical publications making a practice of giving definite and full details concerning the construction, performance and requirements of mining, quarrying and industrial machinery. Information of this order appears sporadically in the engineering and technical press, but at present no American periodical devotes itself to this field exclusively, with the exception of one of our contemporaries, which covers a portion of the field only, that relating to compressed air and its applications. In Germany there are several papers of this nature. MINE AND QUARRY is endeavoring, in a small way, to supply the deficiency by publishing the details of problems and of their solution, which are constantly being met by the operator, the engineer, and the superintendent, and by giving news of novel applications of old machines, and of new machines and methods which have been developed to meet new conditions. Our readers are urged to present their own experiences in our columns, and to submit problems which they have encountered, for discussion.

The article in this issue on drilling costs at a Newfoundland iron mine will be read with interest by mine superintendents and contractors. The results described show graphically that proper methods of handling men and equipment may make the difference between loss and profit.

The subject introduced in the last paragraph of this article is one on which more light will be welcomed. It is difficult to lay down a general rule for determining the point at which the diminishing efficiency of a part or of a machine requires that it be replaced. In practice few machines attain the evenness of wear of the "one horse shay," as suggested by the writer's statement. Parts wear out in a certain rotation, and, providing the machine is not discarded for one of later design, all parts will eventually be replaced by others, maintaining the machine at a constant degree of efficiency. This degree depends on the care taken of the machine, and the promptness with which worn parts are replaced. On this subject, "When to discard worn members of machines," MINE AND QUARRY hopes to throw more light, and welcomes discussion.



One of the older quarries from which marble has been removed to a depth of 175 feet. Note the manner in which the corner and sides have been cut back into the hill by the Swivel Head Channelers.

QUARRYING MARBLE IN GEORGIA.

Correspondence of MINE AND QUARRY.

The center of the Georgia marble industry is the village of Tate, situated about fifty miles due north of Atlanta, in Pickens County, on the main line of the Louisville & Nashville Railway. Tate lies among the hills, in a little valley formed by one of the sources of the Etowah river. The whole valley, and several of the enclosing hills are practically solid marble, ranging in color from pure white to dark "Creole," with many variations of shade between. The deposits are apparently of unlimited depth, but have not yet been exploited for more than 175 feet below the ground, owing to their large surface area.

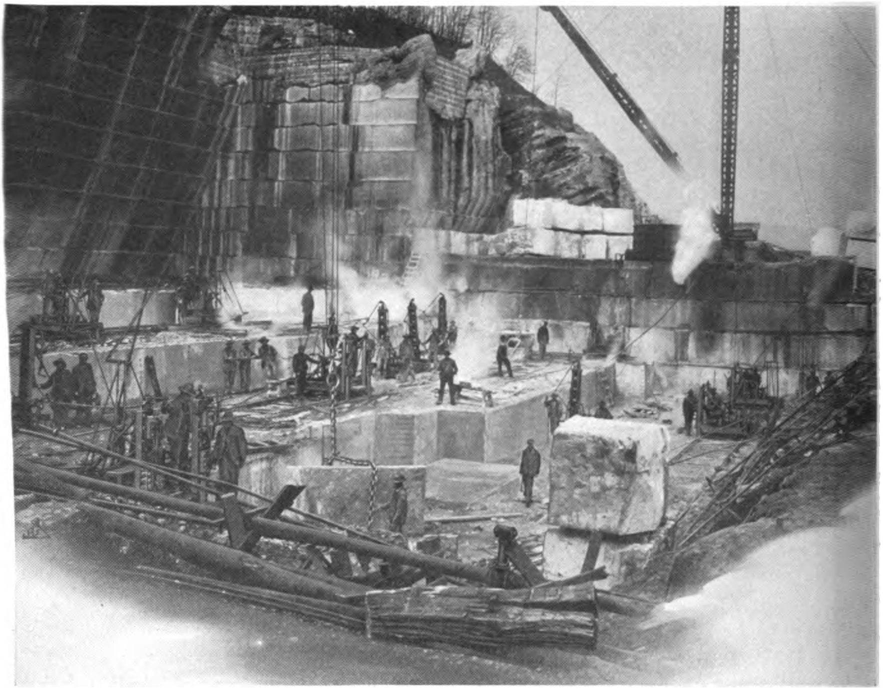
This marble is extremely popular for building and monumental uses in all parts of the country. Its low absorption of moisture, about six one-hundredths of one per cent., renders it practically impervious to weathering in any climate. In this particular, microscopic tests have shown that this stone resembles very closely the wonderful marbles of Greece, which, in the form of temples and statuary, have stood for ages, outlasting all other materials. Georgia marble shows a crushing strength of from twelve to fifteen thousand pounds per square inch, an amount far exceeding any present day building requirements. This is due to its perfect crystalline structure, a characteristic which also explains its permanence of tint, brilliancy, and "life." This evenness of texture also enables it to be worked into the most delicate shapes for ornamental purposes.

The largest operator in this district is the Georgia Marble Company, which has quarried marble here for three generations. The officers of the company are Sam Tate, president; Luke E. Tate, vice-president; S. H. Wright, treasurer, and R. M. Boone, secretary.

At present four quarries are in operation, and a fifth is to be opened shortly. These quarries are: "Creole Number One," 175 feet in depth, with which "Creole Number Two," adjoining, will be eventually connected. The stone worked in these openings is the beautiful mottled gray and white, a sample of which is illustrated on page 63. Next follow "Cherokee Number One" and "Cherokee Number Two," which produce marble of a somewhat lighter shade. The latter quarry is 300 x 100 feet in area. In the "Etowah" quarry, nearby, is found a handsome pink and white mottled stone, widely used for interior decoration. About two miles down the valley is the great "Kennesaw" quarry. The stone worked here is said to be the purest white yet found in Georgia. The illustrations on pages 60 and 61, are from photographs taken during the summer just past. During the summer months over 100,000 cubic feet of marble were removed from this quarry, and an average year's production amounts to nearly half a million cubic feet, or three "floors," each floor containing about 150,000 feet.

The marble in these quarries is cut by means of stone channeling machines, gadders, and rock drills, in the usual manner. The channelers employed are of the Sullivan single gang, direct-acting type, steam driven, size "6½," with swivel-head. This type of Sullivan channeler has been for many years the standard for excavating marble in the great quarry districts of Georgia, Vermont, New York, Tennessee, and other states. Aside from high cutting capacity, their particular advantage lies in their ability to make wall and corner cuts at any desired angle.

Valuable deposits of stone may thus be followed under heavy beds of worthless surface stone, from the main quarry opening, without the expense of stripping. In some Vermont quarries this tunneling process has advanced horizontally several hundred feet under the hills.

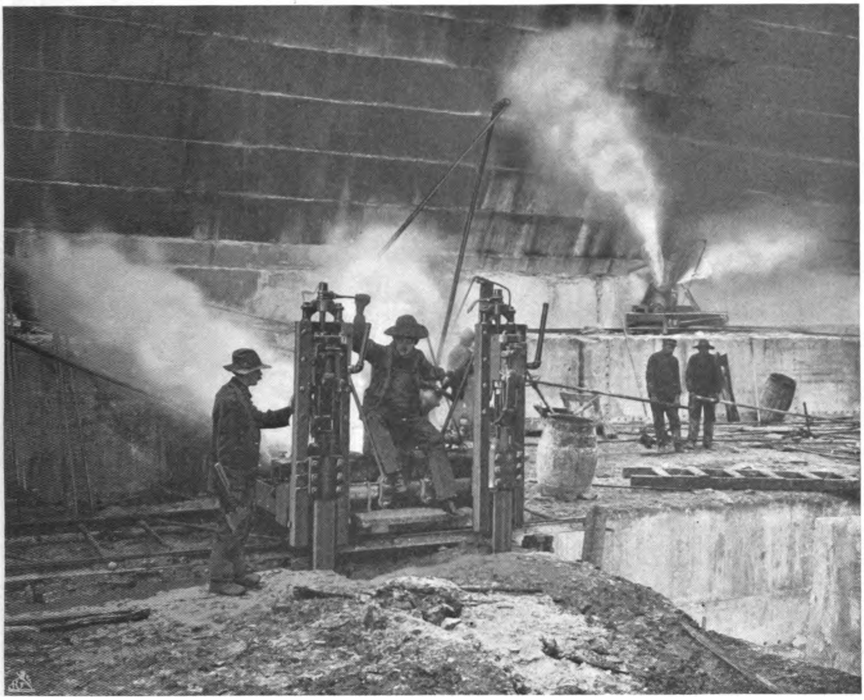


Kennesaw Quarry of the Georgia Marble Co., showing six of the Sullivan Double Head Channelers in operation, also Sullivan Gadders.

It has remained for the Georgia Marble Co. to introduce an important improvement in these machines. The company has employed some ten or twelve Sullivan machines of the above type during the past fifteen years, for angle and corner cutting, performing the level work with double gang channelers of the Wardwell pattern. Some eighteen months ago, the company mounted a second standard and cutting engine, with separate steam connections, on one of the regular Sullivan 6½ machines. It was found that this "double head" machine was able to cut twice as many feet per day as the Wardwell type, on straight work, and as a result, two complete new machines of the "double head" type were recently purchased, and all the remaining single head machines changed to the "double head" type. About fourteen Sullivan "double head" channelers are now in use. One of these machines is shown on page 61, and the general view of the "Kennesaw" quarry, printed above, shows six of them in operation.

In comparison with the single head Sullivan machines, the new channeler will cut about twice as much stone in a shift, either on straight or angle work. This is due to the fact that the same amount of cutting, done by one set of steels in the old type, before they are changed for sharpening, is done by two sets of steel in the new machine, thus the cutting edges are dulled less rapidly. Or, to put it differently, more work can be done with the double machine before changing bits.

With a machine of the new type, 220



Sullivan Class 6½ Double Head Channeler.

square feet have been channeled in 7½ hours, cutting, as usual, to a depth of six feet, whereas 80 to 90 feet is a good day's work for the single head channeler. Aside from capacity, the double head machine is economical of labor, requiring one runner and one helper for its operation, the same number used with the old type, thus saving the labor and wages of two men.

It was supposed at first that high places would be left at the end of the channel cut, but experience has proved that this is not the case. It is unnecessary to run over the ends more frequently than when using the single head type.

Recent improvements to the class 6½ machine include the mounting of the cutting engine on a sliding steel apron or guide, which is gibbed to the standard throughout its length, thus preventing the possibility of side strains. The crosshead is held in its proper position on the guide, by phosphor bronze gibs. A feature of the valve motion is a valve located in the exhaust passage, which by choking the exhaust steam, establishes a steam cushion, preventing the piston from striking the lower cylinder head when the bits pass over a mud seam or cavity in the stone. One of the new machines, embodying these improvements, recently cut 21 feet 8 inches in 20 minutes, or at the rate of 650 square feet per day of ten hours, thus setting a remarkable cutting record.

The Georgia Marble Company also employs a number of Sullivan steel

General view of Georgia Marble Co.'s works, showing the machine shop, power house and mill.

gadders, and class "UC" (2¾-in.) rock drills for general quarrying purposes, at its different operations.

The equipment of the quarries is as modern and complete in all other branches as in that of excavation. The blocks of stone are brought to the surface by eight large, steel, steam derricks, built in the company's own machine shops at Tate. The stone is handled on the surface by a traveling crane of sixty-foot track gauge, recently installed. The track is composed of 100-pound steel rails, laid on marble blocks. Seven miles of railroad connect the different quarries with each other and with the Louisville & Nashville railroad at Tate. This road is ballasted throughout with marble, making one of the finest roadbeds in the world. Two locomotives and a large number of cars form the equipment.

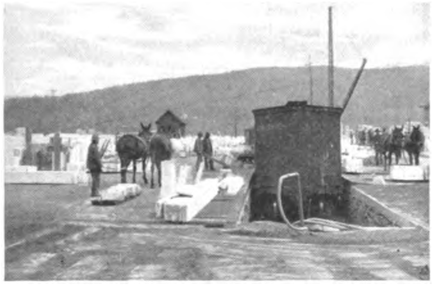
The Georgia Marble Company does no finishing work, but supplies its product sawed to any desired size. Its mill includes thirty-four gangs of saws and two twelve-foot rubbing beds, which run both day and night. The Blue Ridge Marble Co., the Geo. B. Sickels Marble Co., the Kennesaw Marble Co., and the Georgia Finishing Works, handle a large part of the output of these, and other quarries in the district.

The Southern Marble Co., at Marble Hill, seven miles from Tate, is another of the larger operators in this field. Two quarries are now being worked, about a dozen Sullivan channelers being employed. The bulk of their output con-

sists of exterior building blocks and slabs, and monumental blocks, sawed to size.

Georgia marble is widely used in all parts of the United States and Canada, and in foreign countries as well. The state capitols of Rhode Island and Minnesota, the New York Stock Exchange, and public buildings, banks, hotels, mausoleums and monuments in every state in the union have employed Georgia marbles in their construction.

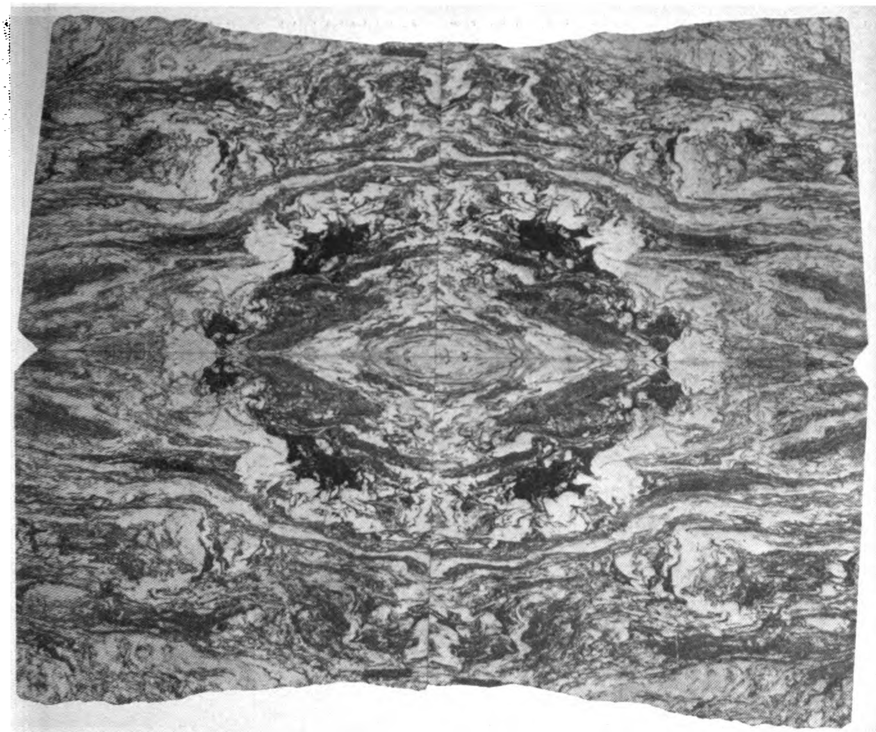
A notable example of the beauty of this stone is found in the Candler Building, recently finished in Atlanta. White marble is used for the exterior, as well as for the corridors, with the exception of the fifteenth floor, which is finished in dark "Creole," wonderfully matched.



View of shipping yard of the Georgia Marble Co.

Four panels from this floor are reproduced in the photograph below.

MINE AND QUARRY is indebted to Mr. Sam Tate, president of the Georgia Marble Co., for the information and photographs used in this article.



Panel from the 15th floor of the Candler Building, Atlanta, showing remarkable matching of "Dark Creole" Marble.

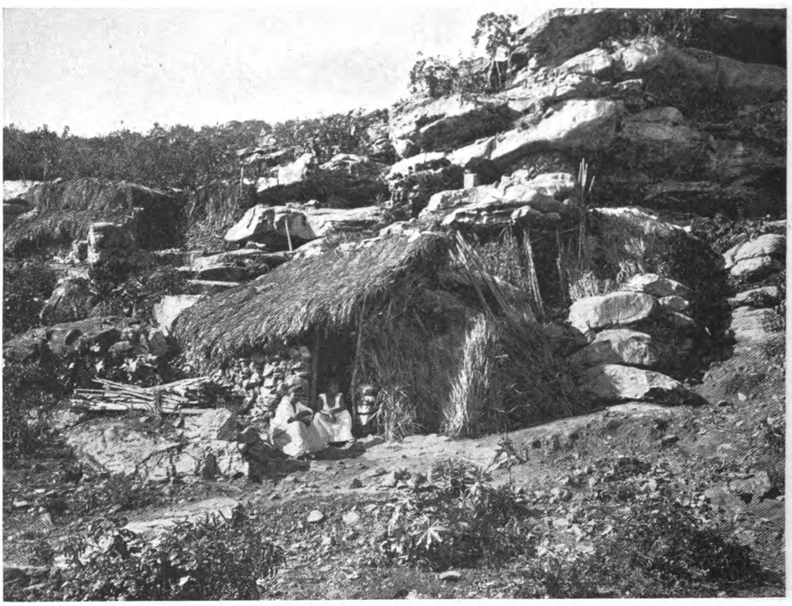
" BLACK DIAMONDS "

THEIR ORIGIN, PRODUCTION AND USE.

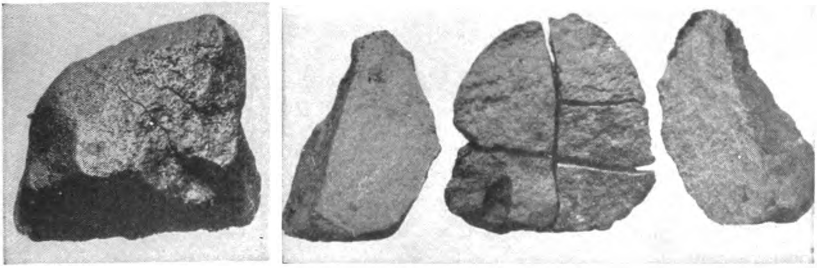
Carbon, or "black diamond," used in diamond drills, is one of the hardest of known substances, being sometimes harder than the "brilliant" or crystallized diamond. It is opaque and amorphous, and is found in commercial quantities only in the province of Bahia, Brazil, in La Chapada and Lavras districts, where it is mined by the natives from alluvial deposits as gold is mined in the placer fields of California. The miners sell their finds to agents of exporting firms in the city of Bahia, from whom it goes to the London, Paris and New York markets. The stones are found in sizes ranging from small fragments up to pieces weighing 100 to 500 karats. We illustrate a stone of 3,078 karats, found in 1895 and proken into pieces suitable for diamond drill work by the purchasers, Messrs. J. Baszanger & Co., of New York, by whose courtesy the cuts are shown. This stone was purchased for $32,000; at the present time it would be worth over $230,000. The term "black" diamond is rather a misnomer, as carbon is seldom found of this color. The stones range in color from black to gray, a dull brown being the prevailing tone. Broken surfaces show steel gray, brown, greenish gray, or in some cases, a pinkish tinge.

Mr. H. W. Furniss, formerly American Consul at Bahia, describes the mining of diamonds and carbon in Brazil, in a recent number of the *Popular Science Monthly*. According to this article, carbons are found in the same formation as brilliant diamonds, but in much larger sizes. This formation was originally a conglomerate, consisting of water worn pebbles, with fragments of sandstone or granite, embedded in a sandstone matrix.

"With the ages a great part of the



Miners' hut, showing ledges from beneath which "cascalho" has been gathered.



First and second stages of breaking.

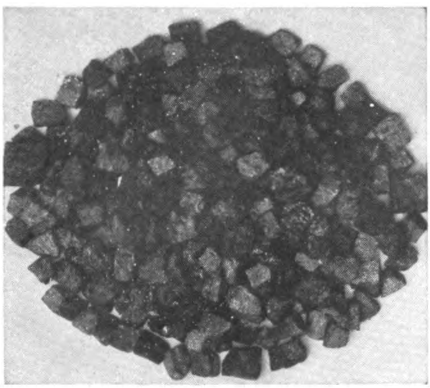
conglomerate has disintegrated and the rains and rivers have washed the diamonds and carbons to the places where they are now being found. There are large masses of conglomerate in many places which have resisted this action, and unless mechanical means are brought to bear, will continue to yield diamonds and carbons for the ages during their disintegration.

"The region about Salobro is comparatively flat, in fact the greatest deposit occurs in an area practically level, doubtless the old river bed. In the other sections of Bahia the country is rocky and mountainous. There is so much of rock and so little of soil that only small plants grow, and then only during the rainy time. In some cases the rivers pass through gorges cut into the solid rock and most precipitous and awe-inspiring. On all sides there is much of interest. The rock formation is a very hard reddish sandstone which completely underlies the conglomerate and like it shows the disintegrating effects of water and climate. In places it has deep cracks which have become natural canals, accumulating with the ages a concentrated diamond and carbon-bearing gravel. In other places immense pieces of sandstone and conglomerate are piled up heterogeneously as if they had been dumped there.

"Most of the mining is done by individuals called 'garimpeiros,' who either work for themselves or on shares with the owner of the claim. In Bahia, the number of owners hiring laborers to work their claims is not more than half a dozen.

"The miners are almost entirely blacks or of mixed race. The greater part of them live in near-by towns, but many have quarters built beneath an overhanging ledge, from which they have removed the diamond-bearing material.

"By far the greater part of the successful mining is still done by antiquated methods, which have the advantage that they require little capital for an outfit. A miner's tools consist of a short-handled hoe with which to stir up the diamond-bearing gravel in a sluice; a crowbar to pry up stones, to lay bare deeper layers or to break down banks of clay or gravel; an iron hook on a pole



Third stage.

Five miners bailing water so that one may collect "cascalho."

with which to take diamond-bearing gravel from beneath large stones or from cracks otherwise inaccessible; a small wooden basin, called "carimbe," for carrying the gravel on the head; a large wooden basis, called "bateia," for final washing and concentrating the gravel; some kind of a sieve, from a tin can with nail holes to a more pretentious wire sieve, for sorting gravel and sand during the washing or concentrating process; a hammer and drill for making holes in rock for blasting, but quite often, instead, a fire is built upon a rock desired to be removed, and after the rock has become very hot, cold water is poured thereon, effectively cracking it and permitting its removal.

"In the home of the carbon there are no carbon or mechanical drills. At present one man can make from two to three holes a day, which with proper methods could be made in a few minutes.

"The method of mining differs in various sections. In the richest areas the work is of two kinds; removing the subsoil surface disintegration and gravel and that in the gullies, cracks and beneath the more accessible stones, or mining by tunnels or following cracks into the pockets of the mountains, taking out the diamond and carbon-bearing material, consisting of soil, sand, gravel, boulders, broken and disintegrated stone, etc., called 'cascalho.'

"The other method is in diving to the bottom of rivers and taking out the cascalho from there. This method is confined to a small section of the district where the river runs through a natural canal cut into the rock. The diving can only be done when the river is low and is chiefly done naked, though there are a few diving suits in use. The naked divers decend a pole planted in the river and fill a sack with the cascalho, which is taken on shore for washing. The ability of some of these men to go to great depths and stay under for long intervals is extraordinary. In some places an attempt is made to work the old river bed, but this is done with great difficulty, as water will seep in almost as fast as it can be bailed out, leaving little time for the collection of cascalho.

Final washing and concentration in "bateias."

"Whatever the method of taking the cascalho out, the great desideratum is an abundant supply of water for washing. Where it is possible, water from mountain streams is conducted down by ditches and flumes, and into these the cascalho is thrown. It is worked with a hoe, by which method the lighter particles are washed away, thus leaving a greater concentration which includes the diamonds and carbons. The concentration is taken out of the ditches and accumulated until the week's end, when it is laboriously further concentrated in bateias.

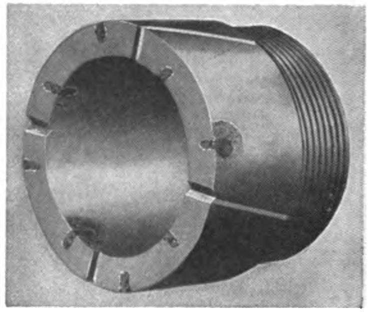
"This final concentration and wash-up requires considerable dexterity as well as strength. It consists in revolving and shaking the bowl so that the portions of heavier specific gravity accumulate in the point in the bottom, while the lighter particles and the large stones are thrown on the edge of the bowl and are from time to time scraped away with the hand, being examined meantime. While the vision of those engaged in this process is very sharp and they will frequently take out from sand and pebbles diamonds smaller than a pin's head, yet from investigation I know that by this method many large diamonds and carbons escape them. This in part accounts for the reason why large diamonds and carbons are frequently found in gravel already washed and picked over. I have heard of places which have been washed for the fourth time and paid, though doubtless in some of these instances the later finds were due to disintegration of conglomerate which yielded up stones heretofore inaccessible.

"The diamondiferous lands of Bahia are owned by the state and leased either as small claims or large parcels to parties or companies desiring to work them. About all of the known areas capable of work with groups without machinery have been preempted. The nature of the work already done has been such that many productive areas have been

covered with tailings. The river beds and other productive sections which will necessitate machinery are still awaiting exploitation."

"Carbonado," as it is called by the miners, was first successfully used for drilling purposes by the French engineer, Lechot, in drilling blasting holes in the St. Gothard tunnel. One of its early uses in this country was for excavating marble in the great quarries of Vermont. The long parallel grooves made by the diamond channelers and gadders are still visible in many of the older workings. Previous to 1880 the price per karat ranged from $2.00 to $10.00 per karat. From that time the use of diamond drills has rapidly increased in all the mineral districts of the world, while the supply from the Brazilian fields remains very limited. This accounts for the current high price of carbon.

Care and experience are necessary in selecting carbon best adapted for diamond drill bits. The stones should be as nearly round or bulky as possible, since thin edges and irregularities make firm setting difficult, and projections wear away rapidly. A small blocky stone is thus more economical than a larger piece of irregular shape. For this reason, practical drillmen often prefer whole or "natural" stones to pieces of a larger "broken" diamond, since the "natural" is frequently water worn and somewhat rounded up. Ordinarily, however, the experienced buyer prefers broken stones to "naturals." The freshly broken surfaces enable him to determine accurately the quality of the stone and its consequent fitness for drilling purposes, while in a majority of cases it is impossible for him to judge of the hardness and "bond" of the grains by the weather-stained appearance of the natural stone. Broken stones which show a closely knit structure with an appearance like that

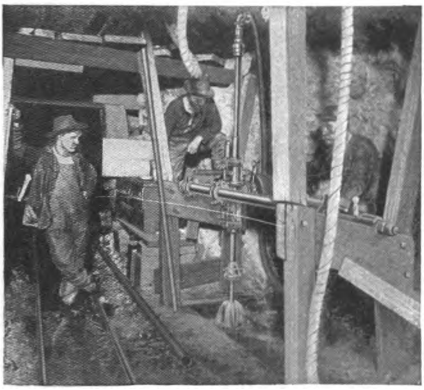


A diamond drill bit set with carbon.

of fine steel when broken, and a gray or greenish gray color, will be found hard and tough, each grain acquiring a polish under wear. Stones showing a coarse or porous grain, like the structure of coke, and which are dull and lustreless, will wear rapidly. The cube is the ideal shape for new broken stones. In examining whole carbons or "naturals," preference is given to stones which show a bright or polished grain; those which are coarse in texture or which show wear without polish, should be avoided. Crystalline or semi-crystalline stones should not be accepted, as they are likely to be crushed under pressure. Good carbon will stand heavy pressure, but break under a blow, so that care must be exercised by the operator in running through broken strata of varying hardness.

Bortz, or imperfect white diamonds, are seldom used at present, in spite of their low price (less than one-fourth that of carbon). Their structure contains more or less flaws, which weaken the stone, while even the best are suitable only for the softer and more regular formations. Their use is thus restricted to coal prospecting and some quarry work, principally in the Central States. Many companies, however, prefer carbon even under these conditions, since wear on the latter is merely nominal, while they are much more reliable.

Persons unfamiliar with carbon and diamond drilling will do well to rely on the experience of the drill manufacturer to supply proper stones, as there is no other material which varies to such an extent in quality, while its present price renders imperative the use of the best to be procured. The manufacturers naturally desire to avoid handicapping their drills by poor carbon, which in the end is much more expensive than the best; and their experience as users of carbon in contract drilling, enables them to select stones from the stocks of the American and foreign dealers, which from their shape and quality will give the most economical service.



Sullivan Diamond Drill boring a horizontal hole in a mine.

STRUCK AN ARTESIAN WELL.

In prospecting for coal on the Cumberland plateau, about fifteen miles south of Eastland, Tennessee, a Sullivan Diamond Drill crew recently had an unusual experience, as shown by the accompanying photograph. At a depth of about 100 feet the drill ran into a water-bearing stratum, with the result that the men at the machine were suddenly drenched by a flood of fresh spring water. The water rose in the drill rods to a height of twenty feet above the ground, and continued to flow, causing discomfort to the crew, while the hole was bored 300 feet deeper. When the outfit was moved away the men left a pipe in the hole, as shown in the picture, and the well is still flowing, a seven days' wonder to the neighboring mountaineers.

CUBIC FEET OF FREE AIR REQUIRED TO RUN FROM ONE TO FORTY PICK MACHINES.

AMOUNT OF FREE AIR PER MINUTE.

No. of Machines	1	2	3	4	5	6	7	8	9	10	12	15	20	25	30	40
4½-inch Cylinder	110	200	290	370	450	530	610	690	770	850	1010	1250	1650	2000	2400	3200
5½-inch Cylinder	130	240	340	430	520	610	700	790	880	970	1150	1420	1870	2300	2800	3700

(See "Machine vs. Hand Mining," page 80.)

CONSTRUCTION PROGRESS ON THE TIDEWATER RAILWAY.

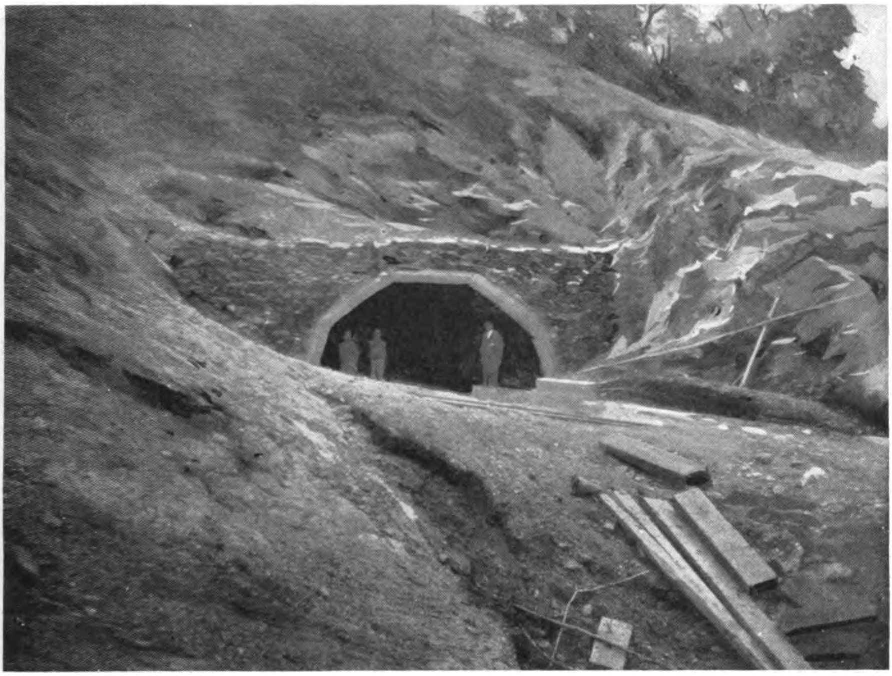
By G. M. Bertram.

The Tidewater Railway, with its West Virginia associate, the Deepwater Railway, extends from the village of Deepwater, on the Kanawha River, about 35 miles southeast of Charleston, to Norfolk, Virginia, where it possesses extensive yards, piers and facilities for storing and loading at Sewall's Point, on Hampton Roads, north of Norfolk. The object of this line is to afford an independent outlet to the seaboard for the West Virginia coals of the Kanawha and New River Pocáhontas districts, which it penetrates for a distance of 85 miles. The line is about 500 miles in length, passing through Fayette, Raleigh, Wyoming and Mercer counties in West Virginia, and touching Roanoke, Lynch's Station and Keysville in Virginia. It is crossed by the Southern Railway, the Chesapeake & Ohio, and the Seaboard Air Line at various points, and generally speaking, parallels the line of the Norfolk & Western, although, as it is purely a coal road, to connect the West Virginia fields with tidewater, it follows the straightest possible course, and does not turn aside to reach large towns and industrial centers. It is thought by keen observers, that it is the intention of the men behind this system, to extend the road to one of the Lake ports, either by connection with some existing line, or by an independent route. This would afford an adequate outlet to western markets for West Virginia coal, at a lower price than is now possible.

The interests behind this large enterprise are understood to be New York capitalists, headed by Henry H. Rogers, who have for a number of years been acquiring and developing coal lands in the vicinity of Ansted, West Virginia, and along Lower Loup Creek. It is understood, however, that the new road will not hold any land in its own right, but will serve impartially all the interests of the districts reached. The officers of the Deepwater Railway are: J. O. Green, president, New York; G. W. Imboden, vice-president, and R. C. Taylor, secretary, Ansted, W. Va.; G. H. Church, treasurer, New York; William N. Page, chief engineer, Ansted, W. Va. This road was chartered in 1897, but until 1903 only four miles of track had been laid, from Dawson to Robson. The Virginia Company was not incorporated until 1904, with William N. Page as president, Thos. D. Ranson, vice-president, and H. J. Taylor, secretary, Staunton, Va.; Geo. H. Church, treasurer, and H. Fernstrom, chief engineer, Norfolk, Va. Mr. Raymond Du Puy, a western railroad man of wide experience, is general manager of both systems, with headquarters at Norfolk.

The singleness of purpose of these companies is shown by the low capitalization, \$175,000 for both, and by the fact that all construction expenses are met promptly as incurred, without calling on the public or otherwise disposing of stock. The 500 miles now under construction, together with the extensive terminals at Deepwater and at Norfolk, will cost \$36,000,000 when completed; and \$14,000,000 additional will be required for an outlet to the Lakes.

Construction is under way from both ends of the system, and practically the entire road is under contract. Sixty-six miles of the road, from Deepwater south are finished and in operation, and it is expected that almost all of the West Virginia work, and 105 miles of line in Virginia west from Norfolk, will be in use before the close of the year. The Deepwater terminals, with a capacity of 400 cars, are completed, and a large equipment of high capacity coal cars and heavy locomotives has been delivered. It is estimated that the entire



Western heading of tunnel at Camp No. 1, east of Lynch's Station, Va.

system will be on a working basis by the spring of 1908.

The location of the line has been planned for years with care, and is such as to permit delivery of the famous coking and steam coals of West Virginia at either lake or seaboard ports at a cheaper rate than is now possible by existing routes. The heaviest grade on the line, found on an eight mile stretch in crossing the Alleghenies, is 25 feet to the mile, while elsewhere two-tenths of one per cent. is the greatest grade. The total lift is only a little over 1,000 feet, while on the Norfolk & Western, which now handles most of the east bound traffic, the lift is 4,000 feet, with a ruling gradient of from 50 to 80 feet to the mile. On account of these remarkably light grades, a single track will be sufficient to handle a very heavy traffic for a number of years to come.

To secure these favorable gradients, the company's engineers have not only located their route to the best advantage, but have not hesitated to run tunnels and make heavy rock cuts rather than turn aside from the path otherwise most favorable. There are literally dozens of tunnels and scores of deep cuts along the road, as well as a number of high viaducts, and in the section between Roanoke and the West Virginia line alone there are fifteen tunnels, ranging in length from a few hundred feet up to nearly one mile in length. One of these long tunnels pierces the crest of the Alleghenies, near Christiansburg, and another is at Glenlyn, on the very border of West Virginia. The tunnels will have a minimum clearance of 22 feet, or five feet more than on other roads in this region. All bridges and viaducts are to be of steel, and 85-pound

rails will be used throughout. All features of construction and equipment are planned upon a similar scale, and no expense is allowed to stand in the way of economical operation.

As stated above, all the work of building the road has been let to contractors, and is now in progress. The line is dotted every few miles with busy construction camps, and the hills re-echo day and night with the roar of blasting, the puffing of locomotives and the clank of drills and steam shovels. The work has been apportioned by the road to a number of well known contracting firms, and each of these contractors has divided his portion of the line into short sections, many of which are sub-let to smaller concerns. MacArthur Brothers Co., of Chicago, hold the principal contract in point of extent and difficulty, their work covering the mountain division between Roanoke and the state line, a distance of from 60 to 70 miles. Lane Bros. Co., of Esmont, Virginia, have a stretch of 32 miles between Lynch's Station and Roanoke, along the Staunton River. The

The Tidewater Railway: Excavating the approach to the 850ft. tunnel, Camp No. 4, Lane Bros. Co., Contractors, west of Lynch's, Va.

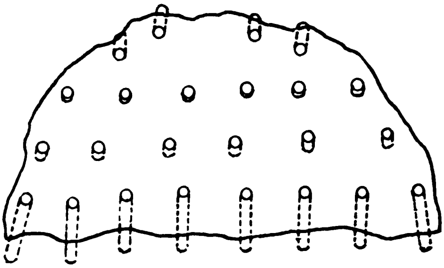
other holders of the principal contracts are The D. A. Langhorne Co., Roanoke, Va., Carpenter, Frazier, Boxley & Co., Clifton Forge, Va., Butler Bros. Construction Co., New York, McDermott Contracting Co., Philadelphia, Pa., A. & C. Wright and W. R. Bonsal & Co., Atlanta, Ga., and Hamlet, N. C., J. G. White & Co., New York.

A brief description of the progress on Lane Bros. Co.'s contract will give an idea of the methods employed and the nature of construction work on all portions of the line. Small portions of the 32 miles included in this section are let to sub-contractors. Lane Bros. Co. have, however, reserved for their own forces the heaviest work, which occurs at their camps, Nos. 1, 4 and 5.

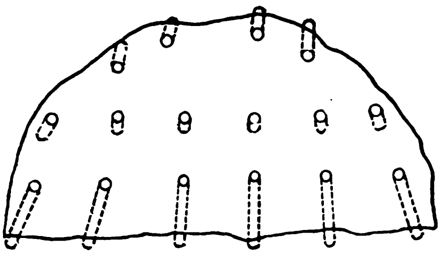
Camp No. 1 is situated on the north bank of the Staunton River, about six miles southeast of Lynch's Station, Va. The Tidewater Railway line follows the north bank of the river, crossing to the south side near its intersection with the Southern Railroad, and continues for a distance of about fourteen miles to Camp No. 4 near Leesville, Va. Just before reaching Camp No. 4, the line crosses the Staunton River and follows Goose Creek for another fourteen miles to Camp No. 5.

At Camp No. 1, a 950-foot tunnel, 26 feet 6 inches high by 22 feet 9 inches wide is well under way. The heading has been driven and timbered for 460 feet, the spacing for the timbers being 2 and 3 feet centers. The size of the timbers is 12 by 12 inches and the lagging is 4 inches thick on the top and 3 inches on the sides. The heading is being driven from the west end only, in order to secure the muck for a long fill at that end of the work. Mr. J. A. Bibb, who is in charge of this work, informed the writer that in the month of September they had driven and timbered 140 feet of heading, 11 feet high and the full width of the tunnel.

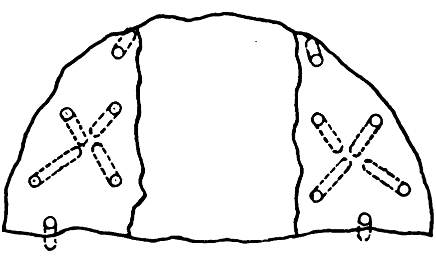
From 4 to 8 hours are consumed



Camp No. 1—Soft rock. Bottom row drop 1 foot below grade, and are shot first. Average depth of holes, 8 feet. Completely shot before timbering.



Camp No. 4—Hard rock. Bottom row drop 1 foot below grade, and are shot first. Average depth of holes, 8 feet. No timber used.

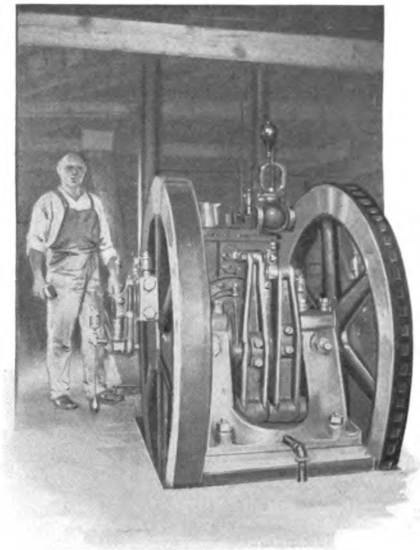


Camp No. 5—Soft rock. Two side cuts drilled and shot first, then timbering started before supporting pillar is removed.

in putting down the round of 24 holes, with two Sullivan UH-2 (3⅝-inch) rock drills, mounted on double screw columns. In fact, the day the writer visited the tunnel, the two drills had just completed a total of 212 feet of drilling in 4 hours, the average depth of the holes being 8 feet. The muck is cleaned out by the night shift. The rock encountered in the tunnel at Camp No. 1 is a soapstone with irregular veins or boulders of white quartz. An interesting method has been adopted for keeping the holes clean in the soft rock. A small foot pump, operated by the drill helper, is used to pump water through a half-inch hose attached to a one-quarter inch pipe, which in turn is inserted in the hole alongside the steel, but not far enough in to interfere with the bit. The bench is to be taken out in two lifts of 8 feet each, after the heading is completed.

The power plant at Camp No. 1 consists of two 80 H. P. locomotive type boilers and one class "WB" Sullivan straight line, two-stage air compressor with a displacement capacity of 909 cubic feet of free air per minute. Only one boiler is fired to take care of the air compressor, which at present is supplying air only to the two UH-2 drills in the tunnel and one UF-2 (3¼ inch) Sullivan drill in an open cut east of the tunnel.

At Camp No. 4 much heavier work is encountered. About 1,000 feet east of the power plant is a cut, 60 feet high in the center, and 88 feet on the high side, after which comes a fill and another cut 90 feet high, originally intended for a 250-foot tunnel, then another very short fill and a 900-foot approach to the tunnel. About 2,000 feet west of the power plant is the western portal of the 850-foot tunnel. The approach at this end, though very high, is short, and the heading is already in 30 feet, and the bench about one-half that distance. At the other end, 85 feet of approach has to be taken out before the heading is turned, and the length of the bench up to the



Sullivan Compressor at Camp No. 4.

portal of the tunnel is about 150 feet. The rock in this tunnel is extremely hard, dark blue in color, with greenish copper stains, and occasional quartz veins. All the cuts above mentioned are through solid rock, the strata lying almost vertically. At present, two Sullivan UF-2 (3¼ inch) rock drills are drilling the heading and then dropping back to drill the bench. There is no night gang at Camp No. 4, owing to lack of labor, and the two drills throw down all the rock that the day muckers can handle. Another UF-2 drill is being used on the approach to the eastern portal, putting down 18, 20 and 22-foot holes. Only one of the two remaining cuts is being worked and this only from one end. The power plant is identical with that at Camp No. 1, with the exception that the Sullivan air compressor is of the improved WB-2 type with rotary inlet air valves on both the high and low pressure air cylinders.

At Camp No. 5 another tunnel and two cuts are under way, and there is also a long cut which has not yet been commenced. The rock in this tunnel is soft, which necessitates timbering, but in the two outside cuts the rock is very hard. In the tunnel only one heading has been turned, and two UH-2 (3⅝ inch) Sullivan rock drills are doing the drilling. Two more UH-2 drills are working in the outside cuts. As in the case of Camp No. 4 there is no night shift. On the outside cut work all the holes are sprung with dynamite and loaded with from 20 to 50 kegs of powder. The power plant consists of one 100 H. P locomotive type boiler and one 900-foot class "WB" Sullivan straight line two-stage air compressor.

The sketches on the preceding page show the methods employed for driving blast holes in the three tunnel headings.

As indicated by the above description, a large amount of equipment is installed by the various contractors on the road. They are much handicapped at present, however, by scarcity of common labor, so that the advantages of this equipment are not yet fully realized. Over 100 Sullivan rock drills, nearly all of the UF-2 and UH-2 sizes, are employed by various firms along the line, also several Sullivan straight line, two-stage air compressors, in addition to the three mentioned above. One of these, having a capacity of 2,450 cubic feet of free air per minute, is being used by MacArthur Bros. in driving the long tunnel at Glenlyn, above referred to.

The usual rate for laborers is $1.50 per day, and the workmen are chiefly Italians and negroes.

The writer is indebted to Messrs. J. A Bibb and J. H. Cheatwood, of Lane Bros. Co., for the information regarding the construction work contained in this article, and for the photographs reproduced herewith. An interesting account of the enterprise in its general bearings will be found in the *Manufacturers' Record* of October 24th, to which publication acknowledgment is tendered for information forming the basis of the first portion of this article.

A SOUTHERN OHIO FREESTONE QUARRY.

The freestone or sandstone of southern Ohio, and particularly of Scioto County, finds a wide market for building purposes, owing to its firm, close texture, which renders it practically impervious to weather, and to the attractive shades of buff, gray and blue in which it is found. The oldest of these Ohio valley quarries, that of M. Coe & Sons, was opened in 1886, near Freestone, Scioto County, on the Norfolk & Western Railway. The deposit of stone now being worked covers an extended area, unbroken by faults, and is about twenty feet in depth. The ledges or beds are practically horizontal and range in thickness from six to fifty-two inches.

Until the spring of 1905, the stone was gotten out by rock drills and hand work. At that time, however, a Sullivan Class "VX" Channeler was installed, thereby greatly increasing the capacity of the quarry. This machine has a steam cylinder 4½ inches in diameter, and is propelled along the track by a separate feed engine. It is the lightest track channeler built, weighing about 1800 pounds. The track gauge is 3 feet 3¼ inches, and one rail is provided on its inner edge with a rack, which is engaged by gears on the trucks, thus enabling the machine to work upon slopes up to thirty degrees if necessary. A three-piece gang bit is used, the outside steels being sharpened at right angles to the cut, and the center steel at an angle of 45 degrees, thus, |\|. In this quarry the channeler cuts to a depth of six feet, and the work is entirely vertical. The "VX" machine, however, has a swivel arrangement which permits it to cut at any angle from vertical to horizontal, and to cut into corners at an angle of nearly thirty degrees. It may be used for cuts up to ten feet in depth if desired. These features render the "VX" a popular channeler for slate and marble quarries. The valve motion secures a rapid, light blow which gives high cutting speed, but does not stun the stone. The machine in Messrs. Coe & Sons' quarry averages 125 square feet per day of eight hours.

After the stone is channeled, it is quarried by rock drills, air hammer drills and hand picks into blocks of suitable size for loading. These blocks are sawed to market sizes, and finished by the Taylor Stone Co., at Rarden, Ohio, and then sold to builders and contractors in all parts of the United States and Canada. The present output of the Coe quarry is about 100 cubic yards of stone per day. The photograph, showing a corner of the quarry, with the channeling machine in the foreground, together with the information used in this article, were furnished MINE AND QUARRY, by Mr. T. J. Coe, of M. Coe & Sons.

Quarry of M. Coe & Sons, Freestone, Ohio.

METHODS USED TO REDUCE THE COST OF DRILLING AT THE WABANA IRON MINES; ALSO THE COST OF DRILL REPAIRS.

(From "*Engineering—Contracting.*")

All contractors and engineers who have rock excavation to do will be interested in the methods that have led to a great reduction in the cost of drilling and blasting at the Wabana Iron Mines of the Nova Scotia Steel & Coal Co.

Mining engineers were probably the first to devise the method of paying for drilling on what is called the "hole-contract system." By this system the number of lineal feet of hole put down by each drill is recorded for each shift, and the drillers are paid according to the number of feet drilled. It is so easy to measure the work done by drillers that no good excuse exists for neglecting to secure daily records of the footage drilled by every machine. One might harp on this fact till the crack of doom, yet there would be numberless men who would call it all "mere theory." A few actual records showing the results accomplished by recording the daily footage drilled, and by paying the drillers a bonus, will be the most effective kind of argument in favor of the "hole contract system." For that reason we shall give, in some detail, the results obtained at the Wabana Iron Mines.

Mr. A. R. Chambers, in a letter to the editor of this journal says:

"I am taking the liberty of sending a couple of forms showing progress in drilling at Wabana, which I trust may be of interest to you. I have been greatly interested in your book on 'Rock Excavation,' which has been of the greatest assistance to me in arriving at the enclosed results, and I am now looking forward to studying with profit your 'Handbook of Cost Data' which I have just received.

"You will notice on the enclosed sheets that one is for October, 1904, and the other for August, 1905. The October sheet is about the first that we used, for about that time we found that something was necessary in order to keep this part of the work from being a failure. Accordingly we devised this form, and it is made up from a daily report which shows the details of the work.

"About January following we obtained the 'Rock Excavation,' and, after following the suggestion laid down there, we found much better increase than previously. Good drillers are paid a bonus, and the list is posted each month.

"The machines used on the work are Sullivan 3-inch "UD" drills. The compressor delivers air up to 80 lbs., but owing to the use of air engines in the mine, when all are thrown together, the pressure is considerably below this most of the time.

"The holes are drilled from 6 to 8 feet deep; and 1½-inch dynamite (40 and 50 per cent.) is used. The drills are mounted on column bars furnished with arms. The seam is 7 feet high and dips 8 degrees. The ore is red hematite of the regular hard ore type, and the drilling record of a drill for one 10-hour shift was 104 feet. We are now installing an 'Ajax' drill-sharpening machine, and hope to obtain still better results when that is in operation."

The drill sheets are 8½ x 13 inches in size, and each sheet is ruled so that the names of twenty-two men can be entered on a sheet. The tables given herewith show how the columns are arranged, and how the records are kept. We have omitted the second column, which contains the names of the drillers.

The value per ton assigned to the ore is entirely arbitrary, and is used merely for the sake of comparison. The next to last column, entitled "Efficiency," might be called "Profits," were it not for the fact that all the items of cost are not shown upon the sheet. The amounts given in this column under "Efficiency" are obtained by subtracting the amounts in the column headed "Total" from the amounts in the column headed "Ore Value."

The rate paid to drillers is 13 cents per hour, and only one 10-hour shift is worked each day; the night shift being given up to blasting, which is not done by the drillers. In the drill sheet, the names of

the drillers' helpers are not recorded. The helpers are paid 12½ cents per hour, but their wages are not entered in these drill sheets; for the main object of using these monthly drill sheets is merely to show the order of merit of the drillers, and the bonus to which each driller is entitled for the footage drilled.

Comparing the drill sheet for October, 1904, with that for August, 1905, we see that each drill averaged 58.6 feet per day in October, 1904, as compared with 69 feet in August, 1905. This is an increase of nearly 18 per cent., but, excellent as this increase is, it is not so striking as the increase in the number of tons of ore broken down by each drill. In October, 1904, each drill averaged 26.2 tons per day; while in August, 1905, each drill averaged 44.5 tons per day—an increase of nearly 70 per cent.! We note also that this remarkable increase in output was not obtained at the expense of more dynamite; for, in the 1904 sheet, only 0.64 tons of ore were broken per pound of dynamite, as compared with 1.2 tons per pound in 1905. The reader can make other comparisons for himself. With reference to the decreased amount of dynamite per ton of ore, Mr. Chambers says that this has been brought about by requiring the drillers to "pay more attention to placing the holes as accurately as possible—to give the dynamite the best leverage; that is, cut holes to meet within about twenty inches, and not overburdening side-holes. It is also partly due to the fact that, whereas we used to run the drift eighteen feet wide, with twelve holes, we now run it about fifteen feet wide with twelve holes, and side shunt to eighteen feet wide with a couple of extra holes. The increased number of feet now drilled per day enables us to do this in the same time."

COST OF DRILL REPAIRS.

The following table gives the cost of repairing twenty-five (Sullivan "UD") drills for eleven months in 1905:

Month of	Total Repairs.	Amount per Drill per Month.
January......	$ 68.32	$ 2.86
February	85.53	3.576
March.......	165.10	6.007
April........	33.92	1.21
May.........	46.98	1.86
June	49.41	1.98
July.........	110.89	4.49
August	316.81	13.50
September...	140.62	5.20
October	259.60	10.66
November...	204.75	7.80

In addition to this add $1.75 per day for labor or 7 cents per drill per day, or $2.00 per month.

The average cost of repairs was $5.35 per month per drill (drills worked one shift only each day), not including the cost of labor of repairing. It takes all of one man's time, at $1.75 per day, keeping the drills in repair, or practically $2.00 per month per drill. The parts used in making repairs are all bought of the manufacturers. We see that the total cost of drill repairs has been about $7.35 per drill per month, or 30 cents per drill per ten-hour day, which is a very moderate cost, and speaks well not only for the make of the drills, but for the care given to them.

Very little has been published on this subject of drill repairs, hence the following letter to the editor from Mr. Josiah Bond, general manager American Copper Mining Co., Somerville, N. J., will prove of value:

"As to the matter of drill repairs, I can give you only a few figures. In using drills for years, I find I have accurate figures for drill repairs for only three years. These place the repairs per drill at $102.00, $100.50, and $93.76 per year. My opinion is that a drill used night and day for a year is sufficiently worn to make it good business to throw it away; though if a drill is used by only one man, and he is made responsible for its condition, I think the life of a drill is at least three years (one shift). Of course studs and side rods will have to be replaced occasionally, and other small repairs must be made. A well made heavy bar or column should outlast four drills, and arms are probably strong enough to kill three

MONTHLY DRILL SHEETS.

NAME OF MINE, No. 1 Slope. AT WABANA. MONTH OF OCTOBER, 1904.

	ORE.					DYNAMITE.		WAGES.				
No.	Cars.	Tons.	Value.	No. of Feet Drilled.	Tons of Material per lb. Dmte.	Lbs. Used.	Value.	Hours.	Value.	Repairs.	Total.	Efficiency.
119	417	688	$583.80	1,437	.57	1,207	$205.19	260	$33.80	$0.83	$239.82	$343.98
164	382	630	534.80	1,469	.60	1,050	178.50	200	26.00	......	204.50	330.30
101	392	647	548.80	1,451	.66	980	166.60	190	24.70	2.92	194.22	354.58
633	397	655	555.80	1,445	.62	1,056	179.52	200	26.00	8.94	214.46	341.34
664	376	620	526.40	1,567	.64	968	164.56	260	33.80	......	198.36	328.04
434	229	378	320.60	811	.77	491	83.47	260	33.80	......	117.27	203.33
416	461	761	645.40	1,501	.70	1,087	184.79	250	32.50	.25	217.54	427.86
82	415	685	581.00	1,501	.71	964	163.88	260	33.80	.19	197.87	383.13
641	419	691	586.60	1,548	.67	1,031	175.27	260	33.80	......	209.07	377.53
70	371	612	519.40	1,426	.59	1,037	176.29	260	33.80	5.50	215.59	303.81
306	388	640	543.20	1,483	.64	1,000	170.00	250	32.50	1.00	203.50	339.70
429	372	614	520.80	1,488	.62	990	168.30	260	33.80	.94	203.04	317.76
65	385	635	539.00	1,391	.67	948	161.16	250	32.50	......	193.66	345.34
411	397	655	555.80	1,425	.65	1,007	171.19	240	31.20	.19	202.58	353.22
	5,401	8,911	$7,561.40	19,943		13,816	$2,348.72	3,400	$442.00	$20.76	$2,811.48	$4,749.92

Drill days, 340; total feet drilled, 19,943; feet drilled per day, 58.6. Output, 8,911 tons (2,240 lbs.); tons per foot drilled, .44; tons per drill per day, 26.2. Dynamite used, 13,816 lbs.; tons per lb. dynamite, 0.64; drill repairs, $20.76; average, .061 per day; average, 1.586 per month. Total efficiency, $4,749.92; average per day, $13.97; average per month, $363.22.

NAME OF MINE, No. 1 Slope. AT WABANA. MONTH OF AUGUST, 1905

	ORE.					DYNAMITE.		WAGES.				
No.	Cars.	Tons.	Value.	No. of Ft. Drilled.	Tons of Material per lb. Dmte.	lbs. Used.	Value.	Hours.	Value.	Repairs.	Total.	Effi'ncy
222	760	1,254	$1,064.00	1,849	1.18	1,060	$180.20	270	$35.10	$3.75	$219.05	$ 844.95
386	902	1,489	1,262.80	1,667	1.94	767	130.39	270	35.10	....	165.49	1,097.31
470	774	1,277	1,083.60	1,617	1.48	860	146.20	250	32.50	37.00	215.70	867.90
79	275	455	385.00	823	1.01	450	76.50	110	14.30	6.00	96.80	288.20
209	35	58	49.00	118	.90	60	10.20	20	2.60	....	12.80	36.20
70	496	818	694.40	1,392	1.20	677	115.09	230	29.90	24.50	169.49	524.91
286	708	1,168	991.20	1,971	1.17	995	169.15	260	33.80	....	202.95	788.25
435	336	555	470.40	947	.95	580	98.60	135	17.55	....	116.15	354.25
309	687	1,135	961.80	1,662	1.29	879	149.43	245	31.85	16.00	197.28	764.52
573	674	1,112	943.60	1,817	1.08	1,030	175.10	270	35.10	5.50	215.70	727.90
245	683	1,129	956.20	1,791	1.17	966	164.22	250	32.50	3.05	199.77	756.43
306	147	243	205.80	408	1.09	222	37.74	40	5.20	....	42.94	162.86
185	535	883	749.00	1,370	1.05	838	142.46	250	32.50	17.95	192.91	556.09
78	750	1,237	1,050.00	1,829	1.29	960	163.20	250	32.50	5.50	201.20	848.80
507	665	1,098	931.00	1,680	1.20	911	154.87	230	29.90	25.50	210.27	720.73
119	553	913	774.20	1,653	1.21	751	127.67	240	31.20	....	158.87	615.33
298	511	843	715.40	1,502	1.00	837	142.29	207	26.91	....	169.20	546.20
411	548	904	767.20	1,615	1.06	853	145.01	190	24.70	24.40	194.11	573.09
	10,039	16,571	14,054.60	25,711		13,696	2,328.32	3,717	483.21	169.15	2,980.68	11,073.92

Drill days, 372; total feet drilled, 25,711; feet drilled per day, 69. Output, 16,571 tons; tons per foot drilled, .64; tons per drill per day, 44.5; dynamite used, 13,696 lbs; tons per pound dynamite, 1.20: drill repairs: 169.15; average .454 per day; average 12.258 per month; Total efficiency, $11,073.92; average per day, $29.76; average per month $803.52.

drills. And the drill itself is the weak part; as soon as the cylinder and piston are enough worn to make a day's work only 80 ft. instead of 120, or even 100 ft., it is clear that you are losing money by keeping it at work. I have always wanted two idle drills and one idle column and arm, etc., for five working drills. From my practice, which has been a pretty hard one, developing with low priced labor, I should estimate a stoping drill, to cost including repairs and its own life about 50 cents per shift.

MACHINE VS. HAND MINING.

The use of machines for mining bituminous coal in the United States has more than kept pace with the remarkable growth of the industry itself. In 1891 the total production amounted to 93,177,978 tons, and in 1905, to 315,259,491. Of the former amount, machines produced 6.66 per cent; of the latter, 32.79. In 1891, 545 machines were in operation; in 1905, 9,184.

The reasons for mining by machine instead of by hand are many, and are often complicated by local conditions. In general, they include the following: (1) The actual cost of mining is lower; (2) the quality of the product is superior; (3) the industry is attended with less danger, and working conditions are improved; (4) the mine may be more rapidly developed, and the production thus increased; (5) application of power to other purposes in the mine, pumps, ventilation, rock drills, etc.

The following discussion of these advantages is based upon the Sullivan Pick Machine, and not upon the Sullivan Electric Chain Mining Machine, although many of the arguments urged in favor of the one apply also to the other. In order to present the above points in concrete form, to operators considering the installation of a machine plant, certain conditions are assumed below as a basis from which an approximate idea may be formed of the fitness of machines for individual requirements.

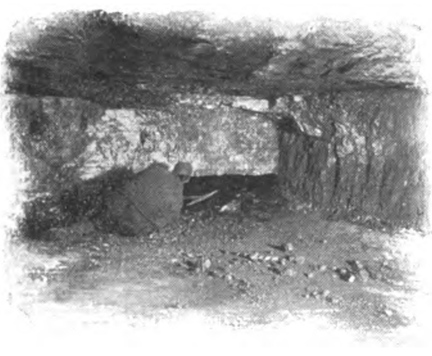
Two cases are assumed:

(1) A mine in which conditions are similar to those obtaining in Pennsylvania, in which machines are substituted for pick mining. (2) A mine in which conditions resemble those in the western fields, such as Illinois, in which machines are substituted for shooting "from the solid."

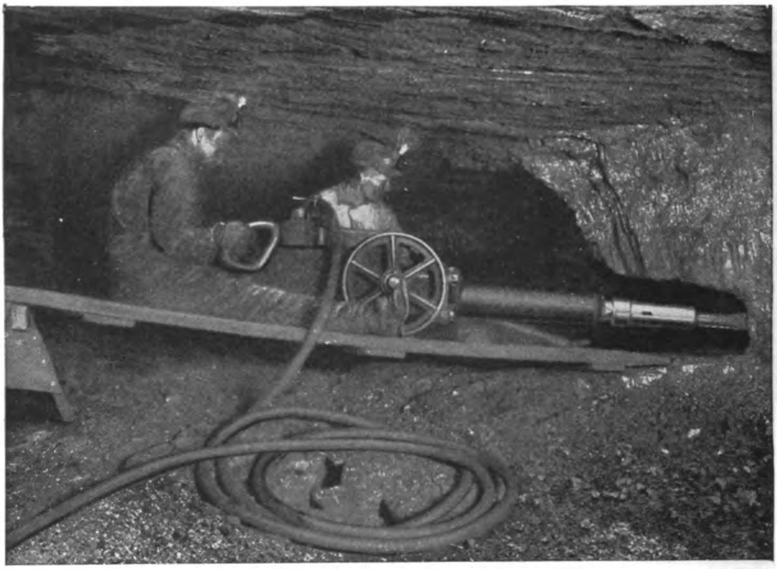
CASE I.

The mine assumed for discussion is worked on the room and pillar plan in a level vein about 4½ feet high; entries, room-necks and break-throughs are driven 10 feet wide; rooms are 25 feet wide, driven 300 feet deep; pillars between rooms are 15 feet wide. This mine is now on a pick basis, with 75 rooms developed, two men to a room, or 150 in all; assuming four tons per day per man, the output from the rooms is 600 tons. To this may be added 100 tons from the narrow places, requiring 50 additional miners, or a total of 200 miners to produce 700 tons per day.

Assuming the coal to be equivalent in hardness to that of the Pittsburg thin vein of Pennsylvania, each mining machine will produce about 50 tons per eight-hour day, cutting 65 feet of face to a depth of 5 feet. Twelve machines will easily mine 600 tons per day and three additional machines will take care of the narrow work. It will thus require a fifteen-machine plant to cut as much coal as is now produced by hand, viz.: 700 tons.



As it used to be done.



Sullivan Pick Machine at work in Eureka Mine No. 35 of the Berwind White Coal Mining Co., Windber, Pa. This Company employs over 600 Sullivan "Punchers."

The cost of a fifteen machine plant may be summarized as follows:

Power plant, including boilers, air compressor, air receiver, feed pump and feed water heater	$ 5,181.00
*Mining machines, including all accessories, and freight	4,125.00
Installation of power plant, including freight, compressor foundation, boiler settings, wooden boiler and engine house, water tank, fittings, piping, labor, etc.	2,260.00
Pipe lines above ground and in the mine, with all fittings, labor and freight	2,484.00
Total cost	$14,050.00

The expense of maintaining and operating this plant may be approximately estimated as shown below:

Interest (6 per cent.) on investment, depreciation (10 per cent.) repairs and renewals on machine and power plant and extensions of pipe lines	$ 2,250.00
Fuel, 6½ tons per day of one 8-hour shift, at 50c per ton, and oil and waste, 50c per day; per year of 200 working days	750.00
One engineer at $75.00 per month; one machine boss and pipeman at $75.00: one blacksmith to sharpen picks, at $60.00	2,520.00
Total maintenance	$ 5,520.00

In the above estimates, outside figures are taken. In actual practice the cost and maintenance of this plant will probably be materially lower.

The direct saving which this plant will accomplish in this field, appears in the form of wages. Experience has established wage differentials in favor of the pick machine as against hand mining, which differ in various districts, but which are generally as follows:—One-fifth of the pick or hand rate goes to the machine runner and scraper, and one-half to the loader, the difference between the sum of these two (plus three cents for drilling blasting holes by hand), and the hand rate, being the differential in favor of the machine. If the pick rate at the mine under consideration is 60 cents per ton, the machine rate will then be 12 cents, and the loading rate, 30 cents. Adding three cents for blasting makes 45 cents, leaving a differential or margin of 15 cents, out of which the operator makes his profit and pays for the plant This applies to mining in rooms, and in

*A table showing the air consumption of Sullivan Pick Machines, appears on page 69.

entries and narrow work the same proportion may be assumed, the difference favoring the machines, owing to the lower amount of yardage. With an output of 700 tons per day, the gross saving will be 700 x .15 equals $1,050 or $21,000 per year of 200 days. This saving represents the wages of 44 hand miners on the basis, assumed above, of four tons per man per day of eight hours. Thus, taking into account the additional employes needed to operate the machines and plant, the mine will maintain its output with from 20 to 25 per cent. fewer men than when on the hand basis. This gross saving will pay for the machine plant, installation and cost of maintenance, interest and depreciation, in less than a year, leaving a net profit of ($5,520 plus $14,050 equals $19,570; $21,000 less $19,570 equals) $1,430, at the end of the first year.

If the plant is operated for more than 200 days per year, the showing will be still more favorable, since the charges for interest, depreciation and wages of engineers, etc., remain the same, while the output of coal is increased. In such a mine, also, additional mining machines may be advantageously installed, thus still further increasing the output without a corresponding increase in operating expenses.

In the instance just described, the wage differential is the principal direct source of profit. Another is the increase in percentage of lump coal. This amounts to from 8 to 15 per cent., since the machine mines from 30 to 40 per cent. deeper than a hand miner, and blocks down the coal higher on the face, allowing it to roll forward more freely with less powder and consequently less breakage.

MINE AREA.—Mining machines will produce a given tonnage from a smaller mine area, or a larger tonnage from the same area, than when pick work is in vogue. The rooms and narrow places are cut more quickly, shot more easily, and loaded out more rapidly, in order to provide fresh working places for the machines. A smaller number of rooms will thus maintain a given output, and the expense for ventilation, drainage and support of roof will be proportionately decreased.

CASE II.

In Illinois, Indiana, Alabama, Missouri and other western fields the coal is frequently 8 or 9 feet high. All coal not cut by machines in these fields is drilled and blasted off the solid.

Assume again a 700 ton mine, in 7 foot coal, in which the men mine and load 5 tons each per day; 120 miners will be needed to get out the 600 tons from the rooms, and 40 may be added for entries and narrow work, making 160 miners in all. These men are paid 55 cents per ton at present rates making the cost of mining, per year of 200 days, 700 x 200 x .55 equals $77,000.

In this coal a Sullivan pick machine undercuts to 5½ feet and averages 75 tons per day. Therefore, ten machines will be ample to mine 700 tons in one shift. Figuring as in Case I, the cost of the machine plant and maintenance will be:

Power plant	$ 5,181.00
Mining machines	2,750.00
Installation	2,260.00
Pipe lines	2,484.00
Total cost	$12,675.00
Interest (6 per cent.) depreciation, repairs, renewals and extensions (10 per cent.)	$ 2,028.00
Fuel and oil	750.00
Engineer / Machine boss and pipeman / Blacksmith	2,580.00
Total maintenance	$ 5,358.00

In Illinois the machine differential is low, being only seven cents per ton, making the total machine mining rate, 48 cents. The cost of mining 700 tons per day by machine, for the year of 200 days is then 700 x 200 x .48 equals $66,200. Deducting this amount from the cost for hand mining, we have $77,000 less $66,200 equals $9,800, against which is the cost

of ($12,675 plus $5,358) $18,033, for the machine plant and its maintenance.

If the differential were the only inducement for the installation of machines in this field, the percentage of machine mined coal would be far lower than it now is (22 per cent. in 1905). The factor which renders the use of machines profitable, is the increased percentage of lump coal which they secure. When blasting down from the solid, the tendency is to use heavy shots in order to secure as much coal as possible. This "hard shooting" breaks up the coal so that fully three-fifths is fine coal or slack. Undercutting permits much easier shooting and allows the coal to roll out with far less breakage. Reports from a number of mines show the amount of lump coal after machines to be from 20 to 40 per cent. in excess of that after solid shooting. In an Illinois mine, where the vein is 7 feet in height, all the coal was for a time mined by hand, but later machines were installed. The percentage of lump coal at once rose from 40 to 75 per cent. Assuming 700 tons per day, as above, this means, at current mine prices (60 cents for mine run, $1.00 for lump), a direct increase in revenue of $98.00 per day, or $19,600 per year of 200 days.

Safety.—The question of safety to the miner is also one of first importance in this and other fields working on a similar basis. The miner pays for his own powder, and consequently the more coal he can bring down at one blast, the better. If the charge is too heavy, if improperly loaded, or if the drill hole is wrongly placed, a blown-out or "windy" shot results, causing dust or gas explosions in the room or entry. The record of accidents of the last year, due to this cause, is appalling. Even if the shot is successful, the working place is filled with powder, smoke and gas, delaying the loaders and making ventilation more difficult. Operators are realizing more and more, that machine undercutting is the best remedy for this danger, since the cut is always of adequate depth and height to allow the coal to roll out with only a small charge of powder. The explosive has two free faces on which to exert its force instead of one, so that the danger of missed shots is greatly lessened. In Alabama, the State Mining Board recently instructed the State Mine Inspector to send a letter to each mine official and superintendent asking that the miners be instructed to undercut the coal instead of shooting it from the solid.

Development.—By the use of machines, a new mine may be opened up from two to three times as rapidly as by hand, since the machines can push forward the entries with much greater speed than is possible when undercutting by hand or shooting from the solid. The operator is thus able to place his mine upon a shipping basis, and to secure returns from his investment much sooner than otherwise.

Labor.—From the miners' standpoint the machine has many advantages. They have learned that instead of reducing wages and the number of employes, mining machines have given more regular and better paid employment to more men. This is due to the necessity of keeping the machines constantly at work in order to realize the largest possible interest on the investment. The machine miner has greater possibilities in earnings than the hand workman. This is illustrated by recent instances in one of the western districts. A Sullivan machine runner cut over 1,600 tons of coal in twelve eight-hour shifts. For this tonnage, at the current wage scale, he received $93.00. Another runner, in the No. 2 mine of the St. Louis & O'Fallon Coal Co., near East St. Louis, Ill., cut 1,382 tons in twelve days, with a Sullivan Class 5 machine, the coal being 6 feet 7 inches high. For this work he received $81.23, and for yardage, $21.77, or $103.00 for two weeks' work. This man averaged 90 tons per shift for

weeks and completed his day's work (the number of places allotted him) in from four to seven hours.

SAFETY.—In addition to the reduction in risk attendant on machine mining, due to the smaller quantity of powder used for blasting, there may be mentioned as another advantage the ventilation furnished by the exhaust air. Again, in the case of a pick mine, the miner must lie on his side, perhaps in a pool of water, if the coal is wet; while the machine runner sits in comparative comfort on his elevated board.

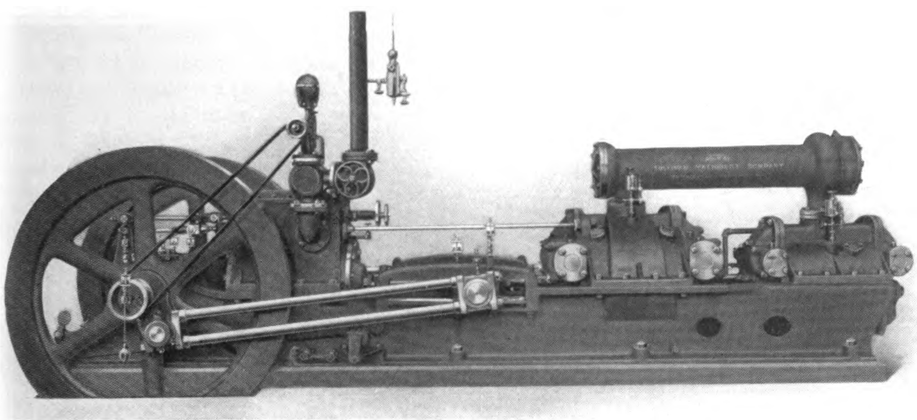
Another advantage—an indirect one, in the use of compressed air mining machines—lies in the application of surplus air power to driving pumps, rock drills, etc. As compared with steam for pumping, air is much more efficient, since it loses but little pressure when transmitted for long distances.

An air rock drill saves much labor and expense about a coal mine. It may be used to advantage not only for sinking shafts, and driving tunnels, but also for lifting rock bottom, taking down roof, and in fact for any work where rock is encountered.

MINERS' HOUSES.—A word may properly be said here about the relation of miners' houses and the company store to mining machines.

It has been pointed out above that by the use of machines, fewer men will be needed to produce a given tonnage than when mining by hand, or that the same number of men can secure a much larger output. The cost of a machine plant for a given production may easily be shown to be materially less than that of buildings, to house a sufficient number of men to do the work by hand, and of a company store. Granting, however, that it is the same, the houses and store serve only to return to the operator a certain portion of the wages of his employes; whereas, the machine plant will enable him to do the same work with fewer men, and to avoid paying any wages to the men not required when machines are substituted.

It has thus been shown that pick machines produce cheaper and better coal than is possible by hand mining, either when picks are used or when the coal is blasted without undercutting; that they diminish danger, and render

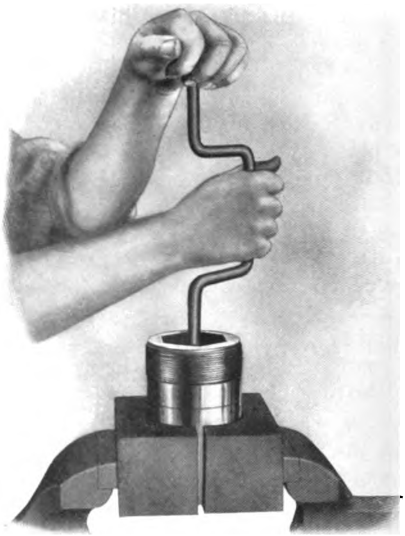


Sullivan Straight Line Two-Stage Air Compressor, Class WB-2. These machines are built in capacities suitable for operating from 2 to 30 pick machines.

working conditions more tolerable; that mines may be more rapidly developed; that surplus power may be put to economical uses; that machines are not antagonistic to the miners' interests; and that an investment in machines pays better than one in miners' houses and a company store. The pick machine may be used for all work done by a pick miner, and achieves economies impossible to the man who mines with a drill and a stick of powder.

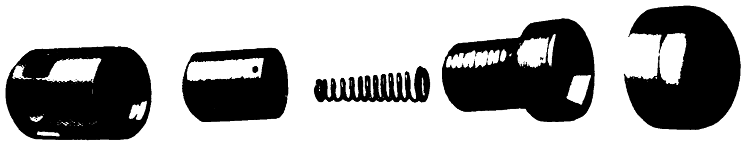
CARE OF DISCHARGE VALVES FOR AIR COMPRESSORS.

The proper operation and efficiency of an air compressor depends upon many features and details of construction and operation, none of which is more important than the discharge valves. In the Sullivan Compressors these valves are of the automatic poppet type, so located as to reduce the element of clearance to the smallest possible terms. It is particularly important that a valve of this type should always act promptly, and seat perfectly, without sticking or leaking, and frequent inspection is essential to see that the valves are in proper order. This inspection in Sullivan machines is a simple matter, owing to the accessibility of the valves, and should be performed at least once a month. After the valves have been thoroughly cleaned and before being replaced, both the plugs and the valve interior should be smeared with high flash test (at least 500 degrees F.) air cylinder oil. Do not use machine oil, as the heat from the air will dry and burn it onto the surfaces and cause the valves to stick. Before replacing, see that the valves show a good bearing on the cage, and that there is no dirt on the shoulders of the cages which bear against the seating on the cylinder castings. Any foreign matter at this point will prevent a good joint, causing leakage of air back into the cylinder. Be sure that the binding plugs are screwed up firmly against the cages, so that the latter can have no end play.



Regrinding the valve and cage together.

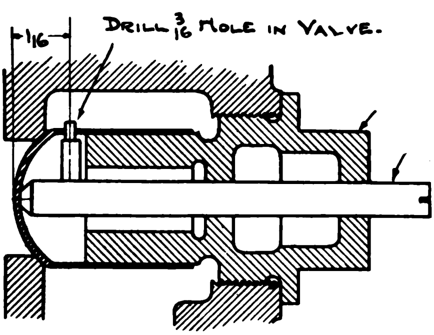
In case a valve needs regrinding, the following method is advised, as illustrated by the cuts. Cut half-round notches, fitting the outside of the cage, in two blocks of hard wood and clamp the whole in a vise, being careful to apply only sufficient pressure to hold the cage from turning. Too much pressure is liable to spring it out of true. Put a wood block or a nut about one inch thick in the bottom of the hole in the guiding plug, before putting in the spring, to increase the pressure on the valve. Slip the valve over the plug and put a nail or short pin through the hole near the upper edge of the valve into a corresponding hole in the plug, so that when the latter is revolved the valve will turn with it. Put a thin, evenly distributed coating of No. 100 or "flour" emery and oil on the seating of the valve and place the plug and valve in the case. A brace with a square point is included in the wrench equipment. Place the



Valve cage, valve, spring, plug and lock nut.

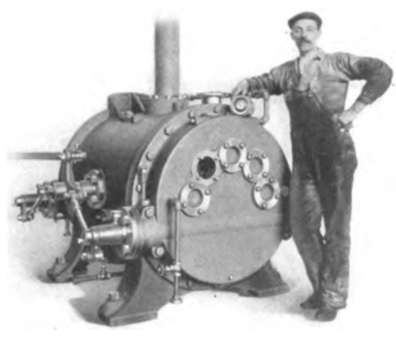
point of the brace in the square socket in the plug and rotate until the valve and seat are ground to a good bearing. Sufficient pressure should be applied so that the plug will enter the counter-bored recess in the end of the cage and hold the valve in line.

On machines in which the valves seat directly on the cylinder, the device shown in the accompanying sketch may be used to regrind the valve and seat. It consists of a plug, inserted in place of the regular valve plug, with a hole through its center for guiding the stem which rotates the valve. The outer end of the stem is slotted for a screwdriver. A 3 1-6 inch hole is drilled in the side of the valve, 1 1-16 inches from the inner end. A small pin is driven in the lower end of the stem, the end of this pin projecting into the hole in the valve. The pin



Assembly of device for grinding 2½ inch discharge valve.

is first inserted in the hole in the valve, then the valve with the drive spindle or stem is slipped over the special plug and the latter is screwed into the valve opening, emery and oil having previously been applied to the seating surface. After the plug is in place the spindle with the valve may be rotated with a screw driver or a bitstock.



Accessible air discharge valves.

It is an excellent idea to have an extra valve, cage, spring and plug on hand, then take out one valve and cage at a time and replace it with the extra one. The valve and cage removed may then be examined, cleaned and refitted at leisure. In this way all the valves will be regularly inspected and any wear or defect discovered before it becomes serious.

MINE AND QVARRY

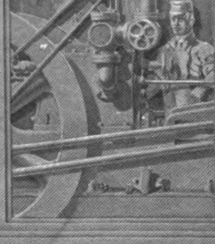
VOL. I. NO. 4. FEBRUARY, 1907

SULLIVAN DIAMOND DRILL TESTING THE BED OF ESOPUS CREEK, BROWN'S STATION, N. Y.

Diamond Drills and the New York Water Supply

The Marble Industry in New York State

Tapping Water in Mines



PVBLISHED BY THE SVLLIVAN MACHINERY CO. RAILWAY EXCHANGE BVILDING, CHICAGO.

TABLE OF CONTENTS

	Page
Editorial	85
Diamond Drills and the New York Water Supply .	86
Tunneling with a Channeler	91
American Drills in a French Colliery . . .	92
The Marble Industry in New York State . .	95
Tapping Water in Mines	102
The Mechanical Sharpening of Rock Drill Steel .	104
Channeling Granite with Hammer Drills . . .	106
Amount of Power Consumed in Cutting Coal . .	108
The Cost of Diamond Drilling	111
Personal	112-A

MINE AND QUARRY

Vol. 1. No. 4. FEBRUARY, 1907.

A Quarterly Bulletin of News for Superintendents, Managers, Engineers and Contractors.

Published by the Advertising Department of the Sullivan Machinery Company.

Address all Communications to MINE AND QUARRY, Railway Exchange, Chicago. Sent to any address upon request.

Readers are requested to notify MINE AND QUARRY of any correction or change in address.

MINE AND QUARRY begs indulgence from its readers for the delay in publication of the current number, which is due to the editor's illness. The May issue will appear more promptly.

The article in this issue on "Tapping Water in Mines," describes an application of the diamond drill fully as valuable as ordinary prospecting service. As compared with the usual method of drifting toward the submerged working, keeping a drill hole a few feet ahead of the drive, the diamond drill is preferable, owing to the entire absence of danger, and to greater economy. The orifice, and consequently the rate of flow, is the same in each case, and the diamond drill accomplishes the desired result much more rapidly. This is but one of numerous special uses to which a mine manager may put his diamond drill, a "by-product," so to speak, which often assumes a value equal to that of the regular use of the machine.

This number completes the first volume of MINE AND QUARRY. The editors have endeavored to make the paper of interest, and also of some practical value to those who have to do with mines, quarries and engineering work, from the standpoint both of the manager or engineer, and from that of the man who comes in more direct contact with the machinery involved. The interest in this paper manifested by correspondence during the year past, is sufficient warrant for its continuance. MINE AND QUARRY thanks its readers for their appreciation, and promises that the coming numbers shall be more worth while than those already issued. A few copies of the May, August and November numbers are still at hand for those wishing to complete their files of Volume No. 1.

In the August number of MINE AND QUARRY appeared an article describing the use of channeling machines in cutting the rock walls of the excavation under Depew Place, in New York City, for the subgrade terminal yards of the New York Central Railroad. In this case, the contractors feared that the jar of blasting would damage the foundations of the adjacent buildings. Consequently channeled wall cuts were made before blasting was undertaken, leaving the rock outside of the lines of the cuts solid and unshattered by the jar of blasting the material between them. The description of a somewhat similar application of channeling machines, printed elsewhere in this issue, may be of interest to engineers having problems of a like nature for solution.

DIAMOND DRILLS AND THE NEW YORK WATER SUPPLY.

The use of diamond drills for making test borings, to determine the character of materials on the sites of engineering structures, has rapidly increased in the last few years. Engineers appreciate more generally than ever, the importance of knowing absolutely what formations must be encountered and what the physical properties of those formations are, before contracts are let or assumed, or the work begun. Weeks, months, or in the case of very large undertakings, years may profitably be spent in such preliminary investigation.

The Panama Canal, the Metropolitan Water Supply Dam of Boston, the U. S. dry-dock at Guantanamo, Cuba, the New York State Barge Canal route, and private enterprises, such as railroad bridges and tunnels, without number, have employed the diamond drill precisely as does a mine manager, to find out what is ahead in the way of mineral or rock, before beginning actual work. For this work the diamond drill is admirably adapted, since it secures a continuous core of all rock strata penetrated, and is provided also with tools and fittings for making wash borings in earth sections.

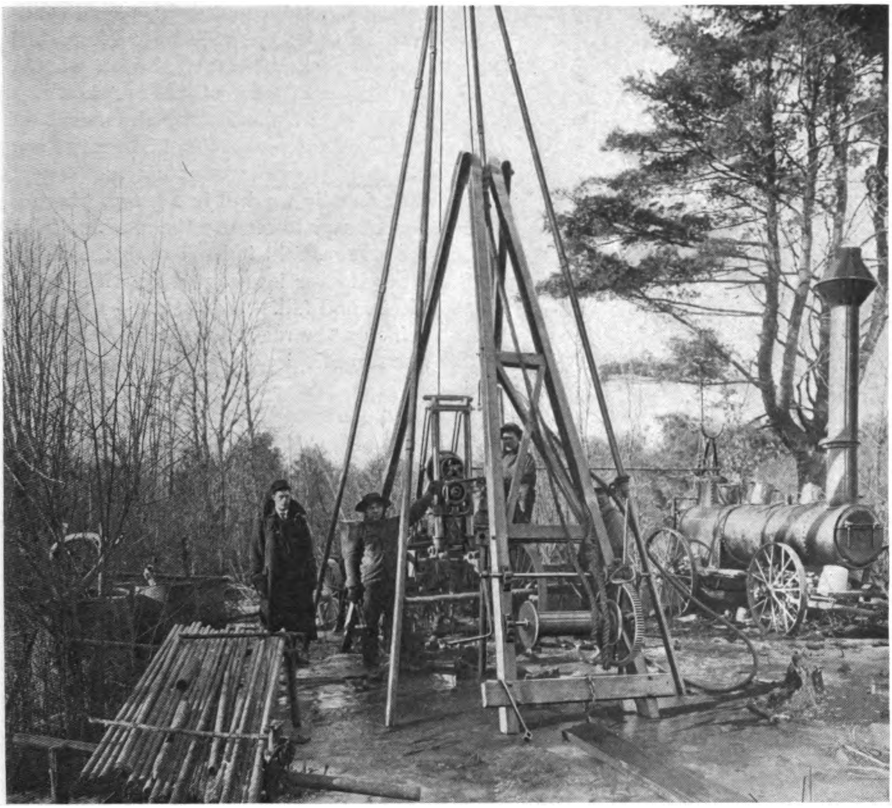
One of the latest and most notable of such examples of foresight is found in the preliminary test work being done by the New York Board of Water Supply, in its task of providing New York City with "enough water." Four watersheds of the Catskill Mountains, those of Esopus, Rondout, Schoharie and Catskill Creeks, will eventually supply reservoirs and aqueducts forming a chain 150 miles long, from the northern limit of the Catskill Mountains to Staten Island. The main aqueduct is to be 85 miles in length, and will empty into a distributing reservoir on the northern boundary of the city. The completed works will include at least 19 impounding and distributing reservoirs. The estimated cost of these works is $162,000,000.

Esopus Creek, yielding about 250 million gallons per day, will be the first source developed, and will flow into the Ashokan reservoir, to be formed a few miles northwest of Kingston by the erection of one large and several smaller dams or dykes. This reservoir will be 12 miles long, with an effective storage capacity of at least 120 billion gallons, the largest reservoir in the world for high pressure water supply. The water collected will cover the ground now occupied by eleven villages, to an average depth of 18 feet, forming an area of 8000 acres, with a shore line of 50 miles.

It is the policy of the Engineering Bureau to make the preliminary estimates, comparisons and investigations so thorough that all essential information shall be secured and preparation be completed before construction is undertaken or the final plans adopted. This policy is justified by the large saving in the ultimate cost of the system by avoiding mistakes and delays and by the greater efficiency of the work for which such preparation has been made.

Two sites for the main dam of the Ashokan reservoir have been considered. Approximately 15,000 lineal feet of wash and diamond drill borings and several deep shafts and trenches have been sunk to explore them. Studies by geologists and comparative estimates of cost based on the information thus gained have resulted in the selection of the Olive Bridge site, nearly a quarter of a mile below Bishop's Falls, shown in the photograph.

It is intended to construct most of the aqueduct on the hillsides, following the contours with a slope of a little more than 1 foot per mile. Where deep valleys are intersected they are to be crossed with inverted syphons, consisting of deep tunnels, driven wholly in solid rock, in some places far below the surface, and shafts, connecting with the adjacent portions of the aqueduct at grade. These syphons will be lined with concrete and



Sullivan "Badger" Drill outfit on Ashokan dam site.

made strong enough to withstand the enormous pressure of the water. The tunnels of the Hudson River crossing may be as much as 500 ft. below the surface of the river, and hence 900 ft. below the hydraulic grade line. Valleys not exceeding 100 to 150 ft. below the hydraulic grade line will probably be crossed by pairs of reinforced concrete pipes about 12 feet in diameter or by several large steel pipes, depending on the results of experiments with reinforced concrete pipes now in progress.

In order to secure the best location of the aqueduct, preliminary lines were surveyed, covering strips in each case about 1000 feet wide, and aggregating nearly 250 miles in length. About 5000 lineal feet of borings with diamond drills have been made to explore the rock, especially at the syphon sites, besides many rod soundings along the cut-and-cover location. Borings and soundings are still in progress. The great depth of water, the tidal movement, and the large traffic in the Hudson River have rendered the examination of proposed crossings tedious and costily. Many lines for this crossing and its connections have been explored, extending over 20 miles of the river, from West Point to a point about four miles south of Poughkeepsie. At the site finally selected, shafts will be sunk on each side of the river, and from stations, cut at the 400-foot level, diamond drill holes will be bored under the

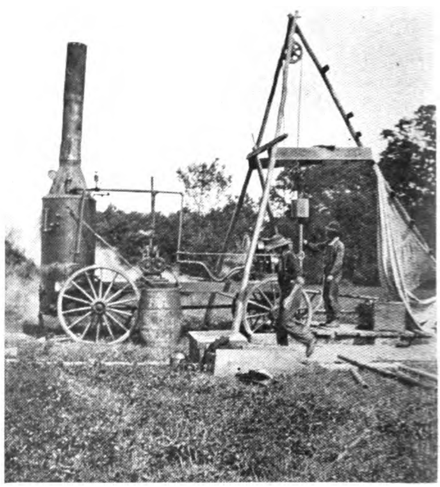
Another "Badger" outfit on the bank of the Esopus river.

river to test the rock formation, before tunneling is begun.

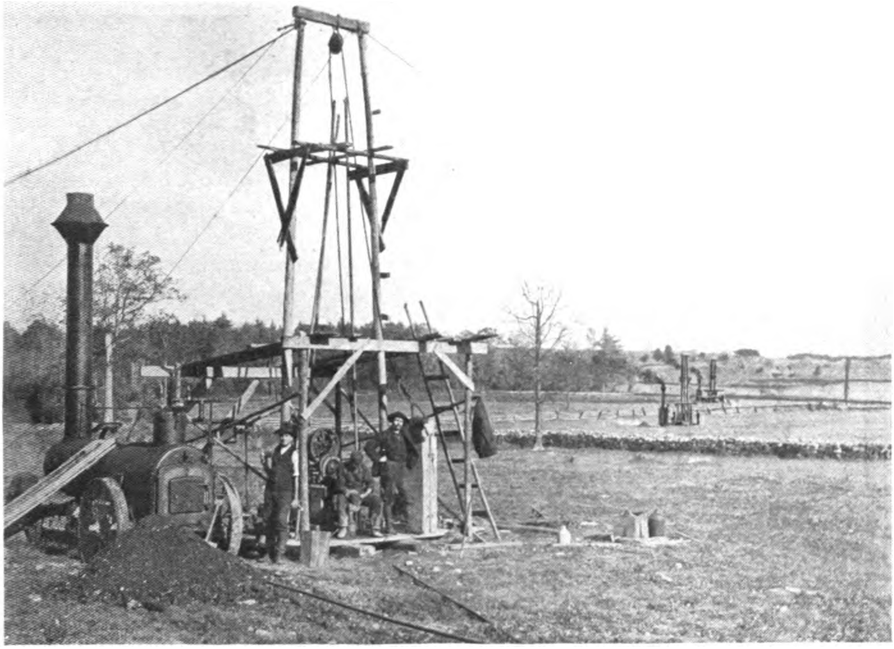
The subterranean explorations have been made with various types of boring machines, and have been executed both by the Engineering Bureau and by contractors. Among the machines in use by the Bureau are four diamond core drills, of the Sullivan "Badger" type. These are mounted on columns for use underground, but are rendered suitable for surface prospecting by telescoping back braces, resting on long skids, which also carry the drill on hinge foot-pieces. These adjustments, together with the swivel drilling head, allow holes to be bored at any angle and in any direction. For future underground work the skids and braces may be removed and lag screws inserted in the ends of the columns. At present these drills are mounted on four-wheel lumber reaches, which can go nearly anywhere that drilling is necessary. A light pipe derrick is erected over the drill hole to handle the lines of drill rods and casing. A hoist on the drill is sufficient for ordinary work, but when the rods or casing pipe must be pulled from the bottom of a deep hole at frequent intervals, in order to shatter boulders with dynamite, et cetera, an extra derrick with a hand windlass is provided. Steam is furnished from a portable boiler, also on wheels. Two views of these outfits are shown.

Mr. E. A. Clark, superintendent of borings, writes:—"We find very few places where we cannot use the wagon. Occasionally we drill in a gorge, where it is necessary to remove the machine from the wagon, fold it back onto the skids, lower it over into the gorge with tackle blocks and fall. We then place the machine on the rocks, on the ice in winter, (see frontispiece) or on a bridge over rapids, or a scow with spuds in still water.

"We frequently make borings from our wagon on side hills which stand at about 45 degrees slope. (See cut on page 88; note two-pole derrick held by guy ropes.) We have in this section, bluestone, shale, slate, sandstone, and other kinds (in boulders). We usually make from 10 to 33 feet in eight hours, taking a $1\frac{1}{8}$-inch core. While you sell the machine for a 15-16-inch core to a 500-foot depth; I believe it would easily take a $1\frac{1}{8}$-inch core to a 600-foot depth. I wish to say further that for a rough country, where



Sullivan "S" Drill at Blake's Farm, Walkill Valley Crossing.



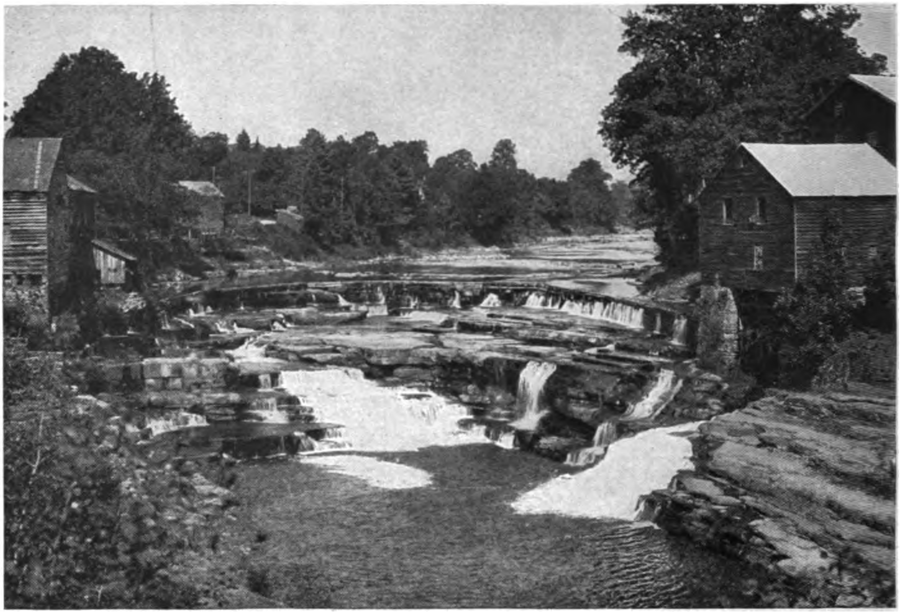
**Sullivan Diamond Drill outfits along the line of the Aqueduct.
Sprague & Henwood, drilling contractors.**

casing has to be sunk from a few feet to 200 feet or more in depth, the combination as above is the best I have seen or used."

A large amount of diamond drill boring has also been done under contract, by Sprague and Henwood, of Scranton, Pa. Four hydraulic feed drills, including two Sullivan "C" and one Sullivan "H" machines, were used on the Ashokan reservoir site, near Brown's Station, to determine the depth and quality of the bedrock. The thickness of the surface deposit varied from 75 to 250 feet, and the holes were bottomed in rock to a depth of 30 feet.

Eight miles to the southeast of the dam site near Kripplebush, the aqueduct passes under a hidden gorge 300 feet deep. Here a shaft 550 feet deep will be sunk, and a tunnel four and one-half miles long driven to the western slope of the Shawangunk mountains. The test-boring for this tunnel, which is on the Rondout section of the aqueduct, was done with one Sullivan "C" drill, one Sullivan "M" hand power drill belted to a Minnesota pipe-driving rig, and a Sullivan "E" screw-feed drill. The last drill, with a home-made steam hoist, put in holes over 400 feet deep, and successfully handled 225-foot lines of 2½-inch extra heavy drive pipe. The materials encountered here included the Shawangunk or Millstone grit, a very fine close-grained rock, closely resembling flint in appearance and hardness.

Some eight and one-half miles further down the line, opposite the village of Forest Glen, in the Walkill division, the Walkill valley is to be crossed by a shaft 300 feet deep and a pressure tunnel six



Bishop's Falls, above Ashokan dam site, 100 feet below high-water level.

miles long. The surface conditions here were exceedingly difficult for drilling operations. The bed-rock, a soft slate, standing on edge, and badly broken, drops rapidly away from the foot of the hills toward the river gorge in the center of the valley. As the depth of the wash increases, boulders become more numerous, and at the greatest depth of surface deposit, they are literally piled together with intervals of a few inches of coarse gravel. These boulders were grit fragments carried down from the mountains, and it was found impossible to blast them without first boring through them with a diamond bit. On this section the contractors used a Sullivan "S" friction feed drill, mounted with boiler and pump, on trucks, and two Sullivan "M" hand power machines, one belted to a Minnesota pipe driving rig, and the other to a five-horse power hoisting engine, with a friction drum for driving pipe.

Wash borings were made in the usual way with double pipes driven by hydraulic jets and hand hammers, the details of the apparatus having been adapted from those ordinarily used for such purposes. There are twelve wash drilling parties, each of them consisting of four men, besides a recorder, who in some cases takes notes for two or more drilling parties.

The records of the drilling parties are kept on daily report sheets and filed in the department offices. The blank for diamond drill reports gives the foreman's name and has vertical columns for the identification number for the hole, the previous number of feet and the number of feet drilled each day. The column footings show the total depth of each test hole and at the foot of the page spaces are reserved for statement of the number of single and double teams used and laborers, etc. The blanks for the wash borings give the name of the line, serial number for each hole, the number of feet previously driven and the number of feet driven on the current day

and the total depth. They also show at the foot of the page an estimate of cost and record of time for the foreman, laborers, teams and extra teams, the rate per day, the total cost and the amount of pipe used.

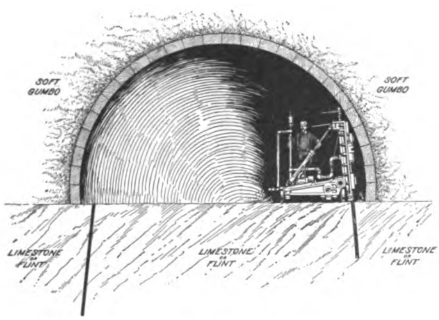
Both these blanks are filled out daily and submitted to the resident engineer. From them he prepares a summary for the department engineer on small blanks, each of which bears the date, the location, the serial numbers of the holes, the depths drilled on the current day, the total depths drilled and the materials encountered.

The Board of Water Supply consists of Messrs. J. Edward Simmons, Charles N. Chadwick and Charles A. Shaw. Mr. J. Waldo Smith is the chief engineer. Mr. Alfred D. Flinn is engineer of the Headquarters Department, Mr. Carleton E. Davis, engineer of the Reservoir Department, Mr. Robert Ridgway, engineer of the Northern Aqueduct Department, and Mr. Merritt H. Smith, engineer of the Southern Aqueduct Department. The consulting engineers are Messrs. John R. Freeman, Frederic P. Stearns and William H. Burr. Messrs. Allen Hazen and George W. Fuller have been retained to advise on the matter of stripping soil from the reservoir bottoms and the filtration of the water. Prof. J. F. Kemp, of Columbia University, and Prof. W. O. Crosby, of the Massachusetts Institute of Technology, have been retained to make a study of the geological problems.

MINE AND QUARRY is indebted to Mr. E. A. Clark, superintendent of borings, Kingston, N. Y., and to Mr. W. S. Osborne Superintendent for Sprague and Henwood, drilling contractors, for detailed description and photographs of the outfits employed in drilling, mentioned above, and to the *Engineering Record* (page 405) for general information concerning the progress of the work, and for the photograph of Bishop's Falls.

TUNNELING WITH A CHANNELER.

In the summer of 1904, while constructing the White River division of the St. Louis and San Francisco Railway system, otherwise known as the Southern Missouri and Northern Arkansas, running from Seligman, Mo., to Leslie, Ark., the contractors, the Kenefick-Hammond Co., were confronted with a difficult tunnel proposition near Harrison, in Boone County, Ark. The grade of the line made it necessary to drive the upper portion of the bore through soft gumbo clay, which caved easily, and had to be supported by heavy timbers. The lower part of the tunnel, six to eight feet above grade, was in solid rock. The contractors were afraid to shoot the rock bench by the ordinary method, since the shock of the blasts would undoubtedly shake the timbers and cause the roof to cave. They thought this difficulty might be obviated if the side walls were freed without blasting. The use of channeling machines was suggested, and a Sullivan Class VX direct acting track channeler installed in the tunnel. The accompanying sketch shows the situation and the method of work. The channeler left a shoulder or offset at the surface of the rock, on which the roof supports rested, and reached the desired depth in two cuts, from three to four feet deep. On one occasion, however, it put in the whole cut, to a depth of eight and one-half feet, in one oper-



VX Channeler cutting walls of a tunnel bench.

ation. The machine was run by compressed air, and used a three-piece gang bit. It stood 5 feet 6 inches high, was 4 feet 4 inches wide on its track, and 4 feet 3 inches long. This machine weighed about 1800 pounds, and had a 4½-inch cylinder.

After the side wall cuts had been completed, the rock between was drilled and blasted in the usual manner, Sullivan US (2¼-inch) rock drills being employed for the purpose. The entire tunnel, 400 feet in length, was driven successfully in this way, without trouble from the roof. The rock was tough flint for about 100 feet, the remainder being limestone. The channeler cut 24 lineal feet 8½ feet deep in the flint, during the first five days it was at work. Later, progress was more rapid, since the cuts were made in two lifts and the limestone was not so hard on the bits. The contractors were much pleased with the successful manner in which the channeling machine solved their problem.

AMERICAN DRILLS IN A FRENCH COLLIERY.

The largest coal mining company in France is the Mining Society of Lens, in the Pas-de-Calais district, producing over 3,000,000 metric tons per annum, or between nine and ten per cent. of the entire production of the country. The magnitude of the enterprise may be in some degree appreciated when it is stated that there are sixteen working shafts, employing over 13,000 miners, who, with their families, comprise a population of over 65,000, occupying more than 6000 houses in Lens and the surrounding villages. There are over 19 miles (in 1903) of main underground roadways, and the equipment includes (1903) 21 hoisting engines, 29 mine fans, 20 air compressors, 39 haulage locomotives, and over 350 rock drills, representing a combined horse power of over 25,000.

Practically all the coal is won by hand, owing to the method of mining. The veins pitch at a steep angle, and are badly faulted. They average about 33 inches in thickness. From the main roadways, horizontal galleries are driven along the vein, the lower portion being in the coal, the upper portion in the solid rock. These galleries are 6 feet 6 inches high, and about nine feet wide. They are driven from 65 to 175 feet apart, and the coal in the vein is then mined between them, from the lower to the upper gallery. This is in effect, modified stoping. The roof is weak, and is carefully supported by props, and broken rock brought in for the purpose. Shoots or passageways are left at intervals, down which the coal is dropped to the lower gallery and there loaded into cars. Ventilation is controlled by means of doors at the foot of each shoot, so that the air follows the working face. The accompanying rough sketch (page 94) illustrates this method of work.

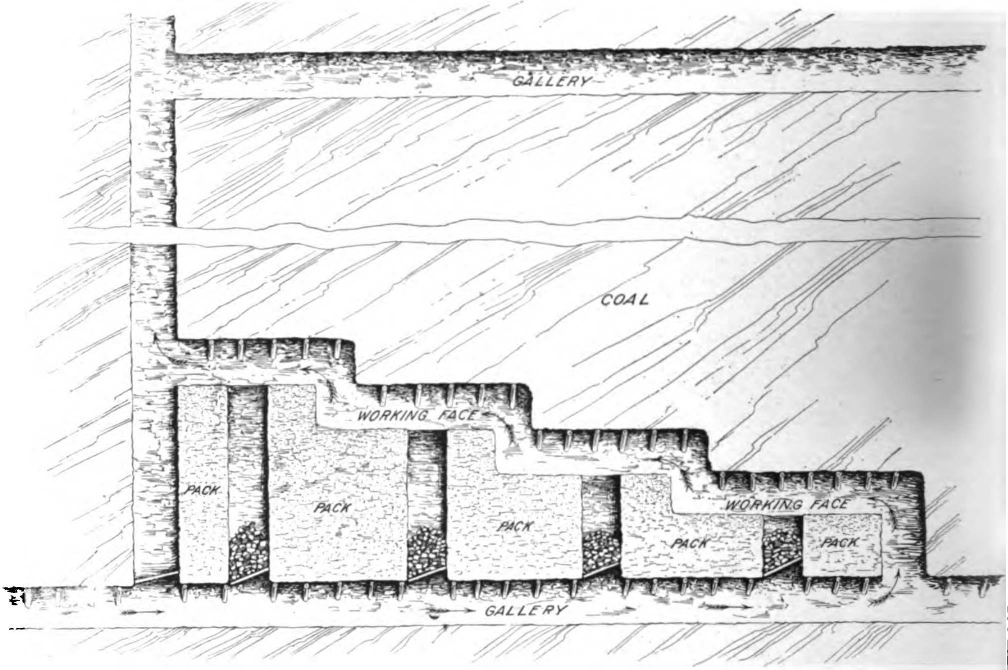
As stated, the pitch of the vein is too steep for machine work. In the entries or galleries, Sullivan Coal Pick Machines are in limited use for undercutting the coal, and rock drills are employed for taking down the roof, which is usually three feet thick and the full width (9 feet) of the working.

Until a few years ago, drills of European make were employed entirely. These machines are large and heavy in design, two of them being permanently mounted on a movable truck. In driving the galleries these machines are able to remove the central portion only, leaving a shoulder on each side wall.

American rock drills, of standard Sullivan "US" (2¼-in.) pattern were tried some half-a-dozen years ago, and it was found that four of these drills, mounted on mining columns, could put in a round of 20 holes which permitted the entire heading to be shot at once; whereas it

"Science guides the work of mining."—See column 1, page 94.

was necessary for the European drills, working on their trucks, to put in 24 holes, even then leaving the shoulders referred to, which had to be drilled and blasted later. Eight shafts, ranging in depth from 300 to 800 feet, and from 18 to 21 feet in diameter, have since been sunk with US drills mounted on tripods. The colliery management is greatly pleased with the American drills, on



Method of coal mining at Lens, France. The arrows show the direction of the air current.

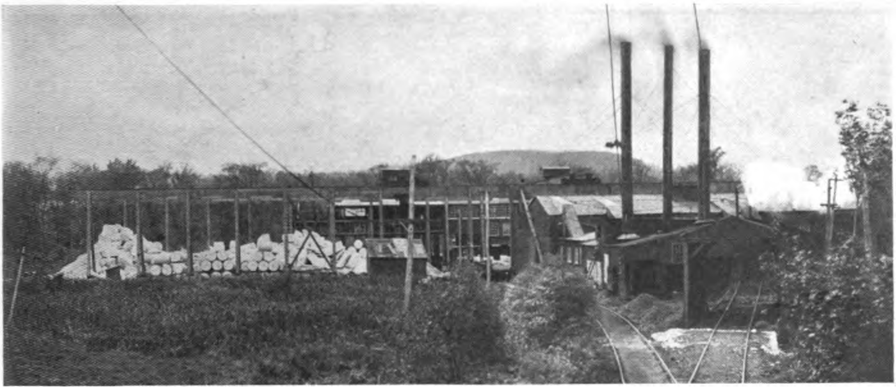
account of their light weight, one third that of the French machines, economy of air and repairs, and greater drilling speed. Between 60 and 70 of the Sullivan US type are now in use, and are replacing the French machines as new drills are needed. The plate on the preceding page is from a photograph of a bronze bas-relief panel which was recently placed above the fireplace in the main room of the company's new office building at Lens. The Sullivan drill, as will be noted, occupies the most prominent position, next to that of Science. The figure of the hand miner below, illustrates the height of the coal, the props which are everywhere necessary, and the safety lamps always used, owing to the presence of gas in the workings.

There is much about this great colliery which would be of interest to American coal operators. The problems encountered in shaft sinking, methods of hoisting and shipping coal, haulage, ventilation, pumping, the life of the miners and their work above and below ground, all contain lessons which mine managers in this country might study to advantage. We cannot forbear to mention a provision for safety which might be put in force to advantage here:—The depth of drill holes for blasting is restricted to one and one-half meters, or about five feet, and when a shot is missed, the hole must be drilled over; the miner is forbidden to touch a hole after it has once been fired.

For information used in this article Mine and Quarry is indebted to Mr. A. de Gennes, M. E., of Paris,* who was for several years superintendent of two of the Lens openings.

*No. 25 Rue Raffet.

THE MARBLE INDUSTRY IN NEW YORK STATE.



Mill and Craneway, South Dover Marble Co., Wingdale, N. Y.

Marble suitable for building and monumental purposes occurs in New York state in two principal localities,—in Dutchess and Westchester Counties in the southeastern portion, and in St. Lawrence county in the northern part of the state.

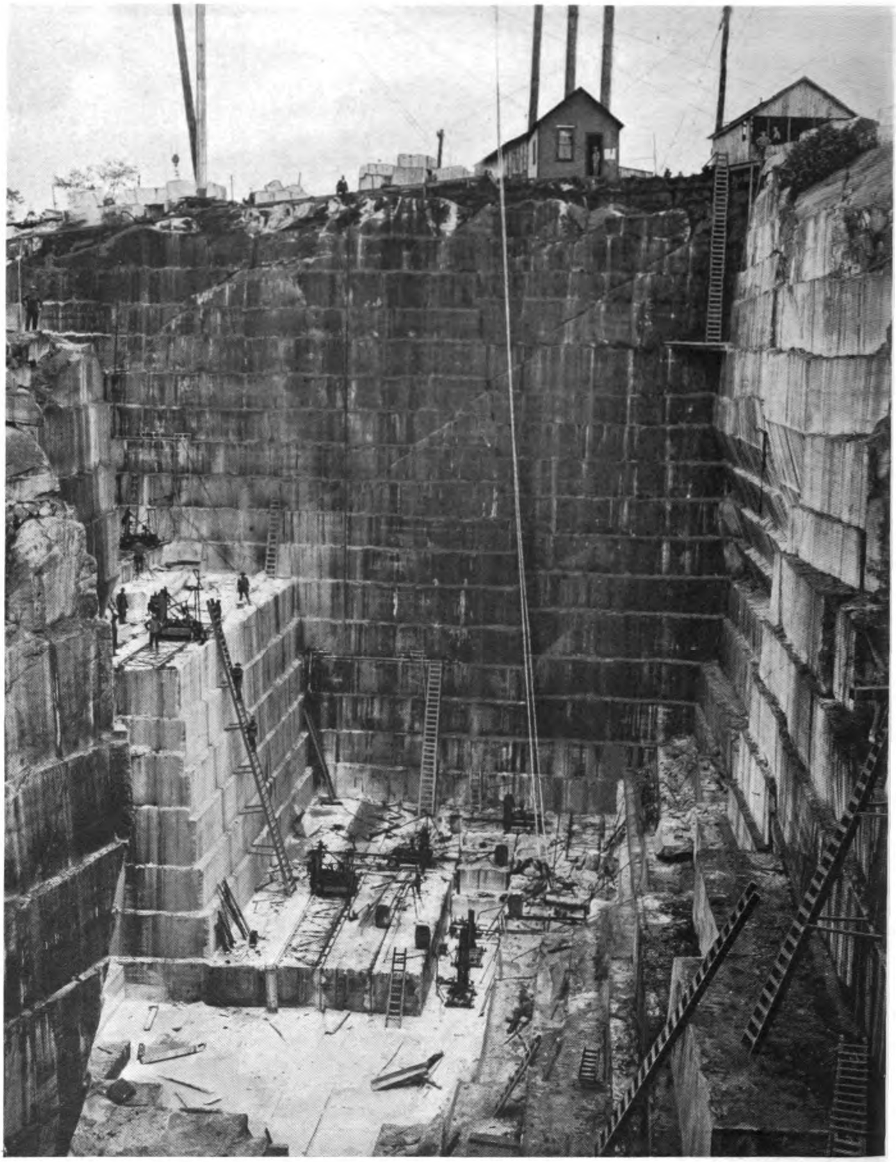
The South Dover Marble Co., with quarries at South Dover, is the largest single producer in the state, and its methods of operation are typical of the quarries in the southeastern field. South Dover is in Dutchess County, close to the Connecticut line, and 70 miles northeast of New York City. Wingdale, three miles distant, is the railroad station, on the Harlem branch of the New York Central lines. The Company's mills and finishing works are here and are connected with the quarries by a private trolley line.

The quarries were opened more than 100 years ago, to work the deposits of dolomite which there occur to great depth. Owing to their inaccessibility, however, they were not fitted and worked with modern machinery until some 12 years since. At this time the electric freight railroad referred to was installed. When first opened the marble was all hauled by teams over the mountains to Poughkeepsie, 25 miles away, and shipped from there by water. The beds slope gently to the east, and are very regular and free from veins, fissures or intrusions of other rocks, a fact which permits solid blocks of pure marble of very large dimensions to be removed for columns and similar purposes. The illustration on page 97 shows a block 29 feet long, weighing 40 tons, being lifted from the quarry. This formed one of 64 monolithic columns, ranging in length from 21 feet to 29 feet ten inches, furnished by this quarry two years ago for the Tiffany Building in New York City.

The quarry opening is about 200 feet long and ranges from 50 to 140 feet in width.

The view on page 96 is from the north side of the quarry, looking south. At this end of the quarry the stone is all of the "White South Dover" variety. In the north end, partly shown on page 98 a popular colored marble is found.

Stone has been excavated to a depth of about 120 feet from the higher side of the hill, and 86 feet from the lower. The marble is excavated by means of Sullivan Class 6½ direct-acting stone channeling machines, of which nine are now in use. One or two other machines



The South Dover Marble Co. General view of quarry, showing Sullivan Channelers and Gadders at work.

are used in clearing away the less valuable surface stone. The Sullivan machines are of the single cutter type, steam driven, except two, recently installed, which are fitted with the double cutting heads which have been found so satisfactory in the Georgia marble quarries. These machines cut much more rapidly than the regular channelers, and the management is greatly pleased with their performance.

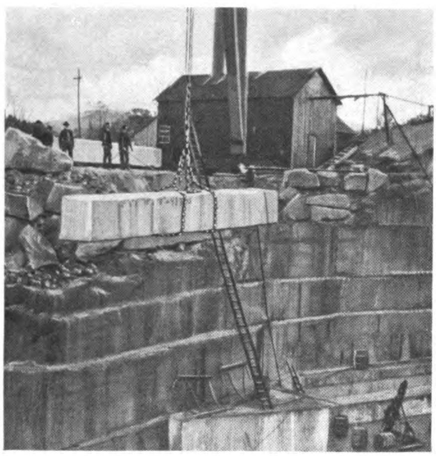
For channeling this rock, the ordinary five-piece gang bit is employed, in which the steels are set with their cutting edges alternately at right angles and diagonally with the cut. The floors, or lifts, are usually six feet in thickness, although seven and eight-foot cuts are sometimes made. Practically all the cuts are vertical, and are made with an offset of about one foot at the end of each lift. The deposits come to the surface for practically their entire width, so that little stripping is necessary, and angle wall cuts or "tunneling" are seldom employed. The photographs show clearly the method of excavating the stone. The blocks are channeled on three sides, and raised by means of gad holes, and plugs and feathers. The channel cuts usually run the length of the quarry floor. When one cut is finished the position of the machine on the track is reversed, and a parallel cut made, giving a width of six feet five inches between centers. The length and thickness of the blocks depend on the work for which they are to be used. The channelers cut from 35 to 50 square feet per day of ten hours, although the double-head machines customarily channel 40 to 50 per cent. more than this.

Channeler runners are paid 25 cents per hour, with a premium of seven cents per foot (five to the runner and two to the helper) for each foot cut over the minimum of 180 feet per week. A foot of wall cutting counts as one and one-half feet; a foot of angle cutting as one and three-fourths feet and a foot of corner or transverse cutting counts as two feet.

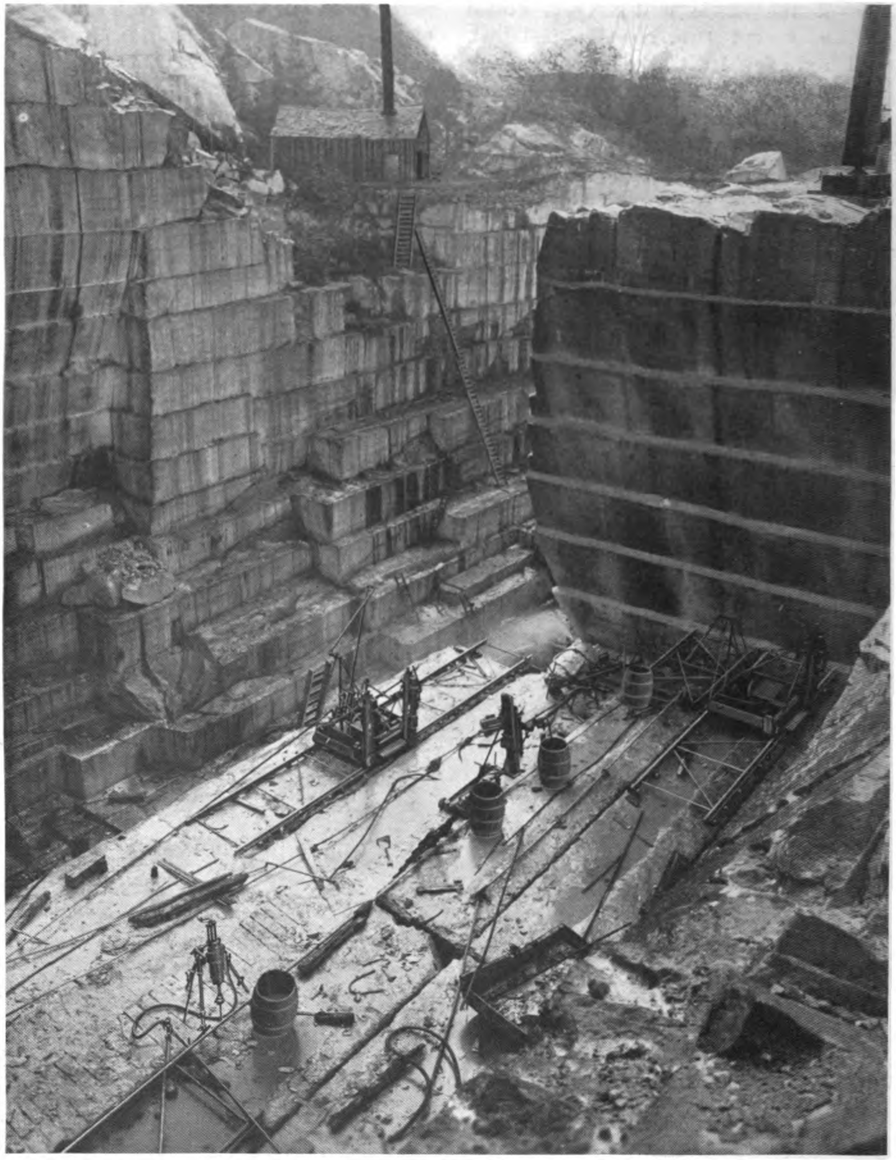
In addition to the channelers, the equipment in the quarries includes a number of Sullivan rock drills, mounted on tripods, gadders and quarry bars.

The blocks of stone are lifted to the surface by four derricks, with a capacity of 10, 20, 30 and 50 tons respectively. Power for the derricks, drills and channelers is supplied by a 400-horse-power boiler at the quarry. The derricks place the stone directly upon cars which transport it over the company's trolley line to the mill. There is also a cableway of 650-foot span, with a lifting power of eight tons. Thus no time and power are wasted in handling the stone.

The views on pages 95 and 100 show the mill buildings, craneway, etc., all of which are thoroughly modern and well equipped. The mill contains six gangs of saws, two rubbing beds, a diamond circular saw and a rotary column-cutting machine with diamond pointed teeth, which cuts columns out of the rough blocks up to three feet 11 inches in diameter. The turning lathes include one for work up to 20 feet in length, and six feet ten inches in diameter, and one



Hoisting a 40-ton block of marble from the South Dover quarry.



The north end of the South Dover quarries. A Sullivan Double Head Channeler is in the center.

with a 30-foot bed and a capacity for turning columns 11 feet in diameter. This is the largest marble lathe in the United States.

The cut on page 100 illustrates the 380-foot craneway, with a span of 72 feet, and the electric traveling cranes, of 50 and 30-ton capacity. In the cutting shed there is a six-ton crane with a run of 250 feet. The equipment of hand cranes, hoists, finishing tools, et cetera, is very complete. Power is supplied by two electric generators of 400 horse-power, which are driven by Corliss engines. A third Corliss engine drives the line shaft for the gang saws. There is also an air compressor, which supplies the finishing tools, et cetera. The boiler plant is rated at 650 horse-power.

The company employs about 160 men, and reports a rapidly increasing demand for its various grades of marble.

South Dover stone has been employed for building purposes in all parts of the country, particularly on work requiring large slabs or columns, as mentioned above. It is largely used for interior decoration, but stands weather so well that it has been employed more extensively for outside work. Among the buildings in which this marble has been used during the last few years, are the Tiffany Building, New York, McKim, Mead & White, Architects; the Blair Building, corner of Broad St. and Exchange Place, Carrere and Hastings, Architects; Mutual Life Insurance Building, of Newark, N. J.; New Stock Exchange (interior), Geo. B. Post, Architect, New York City; The House Office Building, and the Municipal Building, in Washington; The Cleveland Trust Co., Cleveland, Ohio; Essex County Court House, Newark, N.J., Cass Gilbert, Architect, and public buildings in large numbers in New York, Brooklyn, New Jersey, and elsewhere.

The main offices of the company are at 5 and 7 East 42nd St., New York. Mr. P. B. Parker is President, Mr. G. N. Williams, vice-president, Mr. B. A. Williams, treasurer, Mr. A. D. Williams, secretary, and Mr. J. B. Gillie, manager. We are indebted to Mr. Parker and Mr. Gillie for the information contained in this description.

At Tuckahoe, in Westchester County, just outside of New York City, the marble deposits are worked by the Waverly Marble Co. This marble is also used principally for building purposes. The company's equipment includes four Sullivan, Class "Z" swivel head single gang channelers.

ST. LAWRENCE COUNTY FIELD.

The other principal marble district in New York State is in the extreme northern part, in St. Lawrence County, centering about the village of Gouverneur. The crystallized limestone is plentiful in this region, lying on gneiss and, in some places, beneath sandstone. The stone is chiefly used for monumental purposes, and only the gray marble, which occurs irregularly, in some places in beds 30 feet thick, in others only in patches, has value for this purpose. When polished, this stone resembles gray granite and resists the weather well. The poorer grades, containing lighter shades and white streaks, are used somewhat for building.

The companies now active are the St. Lawrence Marble Quarries; Gouverneur Marble Co.; White Crystal Marble Co.; Watertown Marble Co.; Northern New York Marble Co.; D. J. Whitney Marble Co.; Rylstone Marble Co.; and Extra Dark Marble Co. These companies all have mills of varying size adjoining their quarries, except the Watertown Co., whose finishing works are at Watertown.

The quarries are all on the outcrop, and range from 20 to 50 feet in depth. The Whitney and Northern New York quarries are over an acre each in extent. They are practically vertical, and employ the same methods of quarrying their stone as the South Dover Marble Co., described in the first part of this article.

In opening up a new quarry, the out-

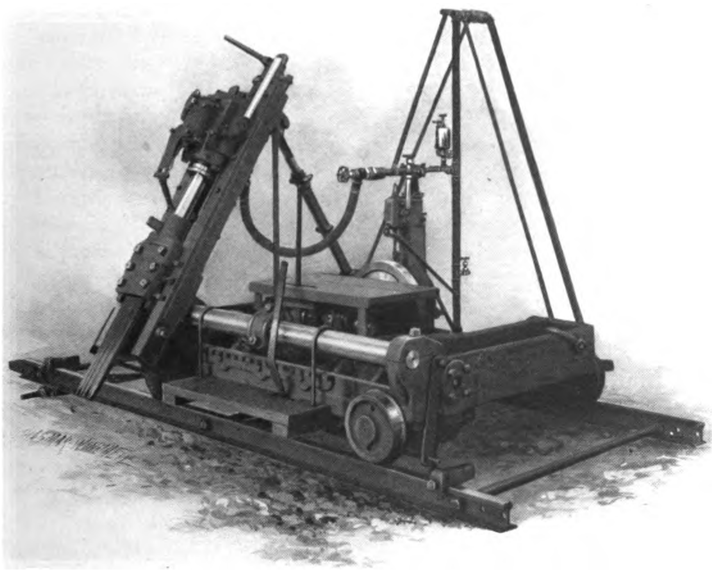
crop is cleared of broken stone and earth, and a water sump is made at the lowest point of the ground to be worked, with rock drills and dynamite. A crane is set up at the edge of the sump, and the ground is leveled off for channeling. The machines used are the Sullivan Class 6½, with five-piece gang steel and swivel head, capable of cutting at any angle. Steam is supplied by the mill boilers, through pipe, with flexible joints, which permit the channelers to move freely back and forth on their track, usually 30 feet in length. The accompanying cut shows one of these machines. The White Crystal Marble Co. also employs a Sullivan Class Y channeler, with rigid head, which carries its own boiler. These machines have a feed engine, which propels them along the track at a speed adjusted to the hardness of the cutting. The engine reverse lever is attached to a long rod which is close to the rail and parallel with it. When the machine reaches the end of the track, this rod strikes a dog fastened to the rail, thus reversing the channeler automatically. The Class 6½ channelers cut from 30 to 60 square feet per ten-hour day, and work to a depth of six feet. The Gouverneur Marble Co. still employs one or two of the old style Sullivan Diamond Channelers, which preceded the direct acting steel type. The high price of diamonds has caused the general abandonment of this machine, which is otherwise efficient and economical of stone.

In opening a new quarry, after the sump is cut out and the derrick set up, as described above, two parallel channel cuts are made, usually 60 feet apart, and at right angles to the sump, rising from

The craneway and finishing works, South Dover Marble Co.

it, so that the cuttings and water will drain into the sump and prevent the formation of a mud cushion under the channeler bits. Cross cuts are now put in 4 feet 8 inches apart, and the key block pulled. This is located under the swing of the derrick if possible. It is channeled on all four sides, and is lifted by means of an eye bolt wedged into a drill hole in the center. The block is freed from the bottom by wedges driven into the channel cut on one side. When this block is removed, the second is taken out by "plugs and feathers." A Sullivan steel gadder is then put to work in the opening, and drills horizontal holes with centers 1½ inches above the floor, if the blocks are to be removed solid (4 ft. 4 in. square x 6 ft. deep) for building purposes; if the stone is to be used for ornamental work, the gadder frame is set at the same angle as the vein of valuable marble, and holes drilled along its edge to separate it from the worthless stone. The view on page 96 shows several of these machines at work. "Plug and feather" wedges placed in the gad holes are used to split the stone.

Acknowledgment is tendered to the *Engineering and Mining Journal* for a portion of the information contained in the above paragraphs.



Sullivan Class 6½ Single Gang Marble Channeler.

TAPPING WATER IN MINES.

The method of removing large bodies of water from old mine workings by means of a diamond drill hole bored from a lower level is not so unusual as suggested by the article, "A Novel Use of Diamond Drills," printed in the August number of this paper. Some 20 odd years ago a hole over 200 feet long was bored under a Chicago city street to drain the stagnant water in an old quarry pit into an active quarry below. The angle of this hole was about 45 degrees, and its actual length was within a few inches of the survéyor's estimate.

The Enterprise mine of the Lehigh Valley Coal Co., near Wilkes-Barre, Pa., which has been idle for over 20 years, on account of the advance of the water, was drained a few weeks ago by this means. A bore hole 300 feet long, drilled from the adjoining Henry colliery, tapped the mine successfully, and has drained off the water in the higher levels, permitting the mining of thousands of tons of good coal. The lower levels are to be drained by pumps.

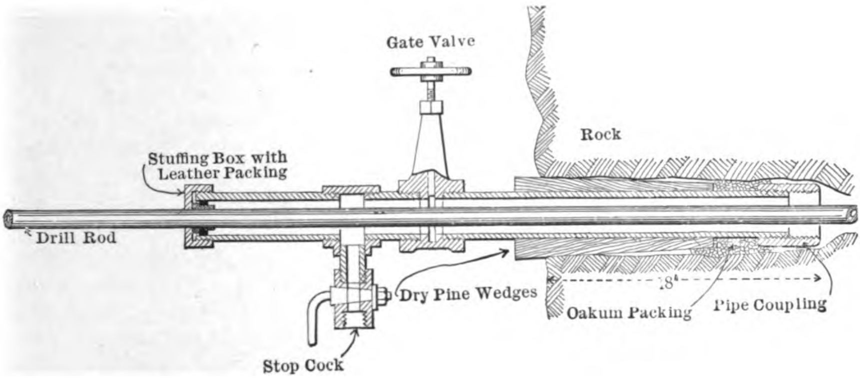
The *Engineering and Mining Journal* recently contained a letter from Mr. H. A. Horsfall, of Yonkers, N. Y., describing mechanism for controlling the flow of water when the old workings are reached. The accompanying sketch shows the method. The bore hole is reamed out for a short distance, and a piece of pipe inserted, with a coupling at the inner end to hold the pipe in place when the water pressure is turned on. The pipe is packed with oakum and wedged into the hole with pine wedges. A stuffing box at the outer end permits the drill rods to rotate freely, and a stop cock is provided to draw off the drilling water and cuttings. The gate valve controls the flow of water.

An Australian correspondent sends a report from Mr. M. Russell, Inspector of Mines at Charters Towers, in Queensland, which describes the process of tapping and removing the water from drowned workings, in some detail. The use of an improvised air lift to drain the mine will be found interesting by users of compressed air. The boring was done with a Class "C" Sullivan diamond drill.

"Regarding the tapping and removal of subterranean accumulations of water referred to in a previous monthly report, I beg to forward a brief outline of the method carried out at the Brilliant Stockholm Mine. After many years of idleness, the Stockholm Mine, lying some seven miles west of this town, was taken up by the Brilliant P. C. Company, who on starting operations decided upon sinking a new vertical shaft to cut the reef some distance below the old workings which were at that time full of water. The new shaft passed through the reef in solid country at a vertical depth of 525 ft., the nearest point in the old workings being some 100 ft. away or more. The question of cheaply and effectively removing the large accumulation of water in the old workings then presented itself to the company. To pump the water through the old shaft meant the expenditure of a large amount of money, besides which the task of picking up the old underlie would have been costly and at the same time a hazardous one.

"After carefully considering the matter, the company decided upon tapping the water by means of a diamond bore, and arrangements were entered into with the Goldfields Diamond Drilling Co. to carry out the work. At a point in the new shaft, 440 ft. from the surface, the boring machine was duly installed, and a 1¼-inch hole put in for a distance of 40 ft. The boring rods were then withdrawn, and 15 ft. of the hole reamed out to 2 in. A 2-in. pipe fitted with a gate valve, and pressure gauge, was next forced into the hole and secured by means of cement. The rods were then passed through the pipe and boring was resumed, the old workings being tapped at a distance of 117 ft.

"While the operation of boring was in progress, a column of 3-in. pipe was



Arrangement for controlling flow of water.

held in the main shaft in readiness to receive the supply on tapping. On account of the great pressure exerted against the boring rods after tapping the water, the task of removing these proved by no means an easy one, and an operation known as fluting had to be resorted to, the rods being removed in short lengths. The rods being removed, the gate valve was closed, and a connection made between the column in the shaft and the horizontal pipe in the hole. On opening the valve the water rose 400 ft. in the shaft column, the gauge indicating a pressure of 180 lb. per square inch. The water in the old workings was now completely under control; and by an ingenious scheme, worked out by Mr. F. Savage, the mine manager, a very large amount of water is being removed at a nominal cost. Mr. Savage passed down the center of the shaft column, an inch pipe, connected on the surface with the main air pipes, and at the lower end fitted with a jet; and, by an almost inappreciable amount of air, the water is now being steadily removed. As the water recedes in the column, the inch air pipe is lengthened from the surface, thus obviating the necessity of breaking the water column from time to time as the water recedes.

"Besides being a particularly safe means of ridding a mine of accumulations of water, the above method has proved to the company by no means an expensive one, the boring of the 117 ft. costing only £150. The other appliances used in connection with the work would have been necessary had other means been adopted to remove the water.

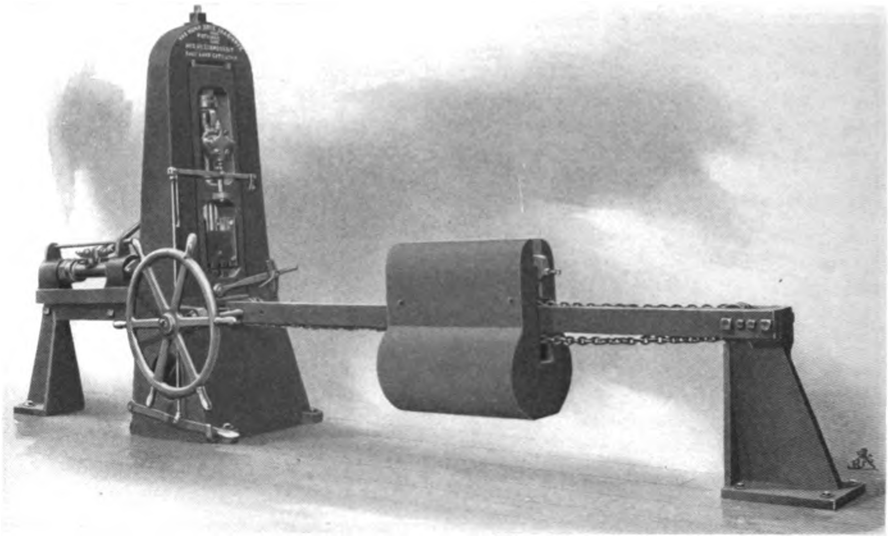
"The whole of the work was completed in the short space of ten days, and the men in the sink below were removed only for three hours during the withdrawal of the rods and making the necessary connections.

"From an inspector's standpoint the above method is an ideal one as compared with the practice so commonly adopted of simply driving towards the water and carrying a hole a few feet ahead of the drive; and I think it would be well to insist, wherever practicable, on a similar method to that so successfully used at the Stockholm, being used in all cases where any danger exists.

M. Russell, Inspector of Mines.
Charters Towers, Sept. 6th, 1906."

THE MECHANICAL SHARPENING OF ROCK DRILL STEEL.

By Matt. Brodie, M. E.*



The "Numa" Rock Drill Maker and Sharpener.

It is a well demonstrated fact that the accuracy with which drill bits are formed and sharpened greatly influences the capacity of a rock drill. The maintenance of drill steels is an important item in the cost of rock drilling, and during the past few years the making and resharpening of drill bits by machinery has undergone a rapid extension and reached a thoroughly practical stage. Almost every mine using a considerable number of drills, today includes one or more drill-sharpening machines in its equipment.

The different machines on the market are similar in general design, and usually consist of a horizontal hammer for upsetting the steel, a vertical hammer for drawing out the bit edges and an adjustable anvil block. The superiority of any one machine over others consists in its strength, speed, simplicity of operation and the perfection of the finished bit. In virtue of these qualities the "Numa" Drill Steel Sharpener, invented and manufactured by J. J. Brossoit, Salt Lake City, Utah, has found extensive use by the larger mining companies and contractors throughout the west, and is being shipped to the Michigan districts and to British Columbia.

A glance at the accompanying general view will give some idea of the strength of construction. The main vertical frame is cast in one piece and has a very liberal base, insuring a minimum vibration under the most severe service. This frame is cored out for the vertical engine frame. The anvil block is provided with roller bearings and is supported on a single rectangular rail, extending the entire length of the machine. The adjustment of the anvil block, for different lengths of steels and for upsetting, is effected by means of a chain running from the main frame to the front end, and a large hand wheel on the operator's side of the main frame. This block is of

*128 Keith Building, Salt Lake.

ample weight to resist the impacts from the horizontal hammer while upsetting the steel.

The vertical engine frame is a solid casting fitted and keyed into the main frame, and cored out to receive the cylinder and cross head guides. The cylinder and piston are a modified 2½-inch or 2¾-inch Sullivan rock drill, the cylinder size depending on the class of work to be done and the air pressure available. The valve chest is of the standard Sullivan rock drill type provided with a stem extending through the lower end. This stem is connected, by levers and rods, to the foot treadle at the base of the main frame, and is held up by a compression spring directly under the valve chest. The stem holds the spool valve, inside the chest, in a position which keeps the vertical hammer at its highest point, thus allowing the steel being sharpened, to be passed back against the horizontal or upsetting die. By pressing the foot lever the valve on the vertical engine is released and the vertical hammer operates as long as the treadle is held down.

The frame for the horizontal engine comprises a continuous base, the front and back cylinder head blocks and the horizontal die guide block, all in one casting. It is securely bolted to the main frame, the through rail and the back pedestal. The cylinder, piston and valve chest are identical with the vertical engine, except that the valve is held or released automatically by the horizontal die. As soon as the operator forces the steel against the die, by drawing up the anvil block, the horizontal hammer begins to strike, and continues to do so until the steel is withdrawn from the die, when the valve is automatically stopped. This device effects a great saving in time and simplifies the operation of the machine.

The most distinctive feature of this machine, however, is the fact that both the vertical and the horizontal hammers work in the same vertical plane, thus eliminating the necessity of lifting the steel from the upsetting dies to the drawing out dies, and vice versa, which is necessary in other machines. As it is always necessary in making or sharpening bits to alternate several times between the dies for upsetting and drawing out, this arrangement results in a considerable economy both in time and in actual labor.

The dies are made of the best tool steel, and are easily and quickly removed and replaced by others for the different sizes of bits or shanks to be made.

The following operations are necessary in making new bits from round or octagonal stock. Heat about 5½ inches of the end of the steel and hammer it between the vertical dies until the ribs are laid out and thin enough to drop fully into the grooves in the dies. Then release the foot treadle, stopping the vertical hammer; rest the shank end of the steel in the recess in the anvil block, and force the steel against the upsetting die by means of the hand wheel, thus automatically starting the horizontal hammer. Continue to alternate flattening out the ribs and upsetting until the bit is well formed, taking care to turn the steel over frequently to insure evenness of the gauge on all sides. Then hold the steel so that the bit end is on the front part of the vertical dies, which are beveled, and draw out the bit edges with the vertical hammer. With a little persistent practice a mine blacksmith or helper soon becomes able to rapidly make or sharpen perfect bits. By sharpening all the steels which are of one length and then changing the dies for the next length, etc., the gauge will be very accurately maintained. These machines are furnished in sizes to handle steel of any desired length and bit gauge, the only change necessary being in the length of the bar on which the anvil block runs.

A brief comparison between sharpening by hand and by the "Numa" machine may be of interest. According to the writer's experience, an average mine blacksmith with helper will resharpen by hand about 35 drills per hour for, say, a nine hour shift, while with this machine

one man will sharpen about 60, and with a helper about 90 drills per hour. These figures are not what would result from a short test run, but are what should be expected as an average per hour for the entire shift.

One of these machines was installed at one of the large copper mines in Bingham, Utah, about two years ago and below are tabulated the labor costs per shift for sharpening drill steels before and after installing the machine:

BY HAND.

3 Blacksmiths at $3.50	$10.50
3 Helpers at $2.75	8.25
Total	$18.75

BY MACHINERY.

1 Blacksmith	$3.50
1 Helper	2.75
Total	$6.25

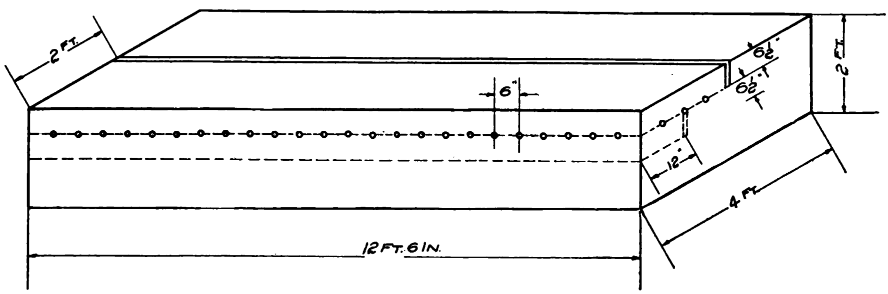
A saving in labor cost of 66 per cent, or $12.50 per shift.

CHANNELING GRANITE WITH HAMMER DRILLS.

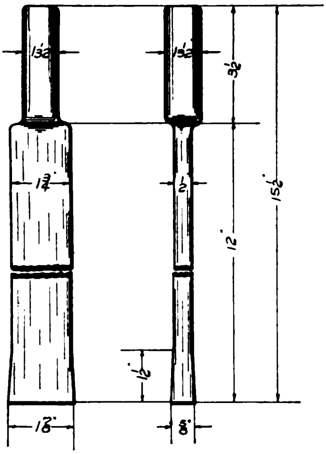
The accompanying sketch illustrates an instance of labor saving in quarry practice, by means of a new type of air hammer drill. The work done consisted in cutting one of a set of steps out of a solid block of granite, at the quarry of Jones Bros., Barre, Vermont. The steps were each 12 feet 6 inches long, one foot wide and 6½ inches high. The step removed, being the first, was two feet in width, as shown by the rough sketch. The drill operator first sank a line of 1¼-inch holes along the back of the step, ⅜-inch apart. He then broke out the partitions, using the broaching bit shown in the second sketch. This part of the work required only a few seconds for each partition. When this channel was finished, plug holes were drilled on the side and ends of the step, and the whole block of stone split off bodily. The quarry manager was greatly pleased with the result. The usual method, hand hammer and bull set, would have taken one man a week, whereas the drill did the work in half a day.

Barre quarrymen expect to apply the same method to much of their ornamental and monumental work, such as cutting out crosses, watering troughs, and in fact any pieces of irregular shape which may be roughed out of the solid stone by means of channeling. The machine used in the instance described was a Sullivan Foot Hole Drill, class D-19, using hollow drill bits and weighing 30 pounds. Its cylinder diameter is 1½ inches, and it uses about 25 cubic feet of free air per minute at 100 pounds pressure. It is suitable for drilling holes up to 1⅝ inches in diameter, and from one to four feet in depth.

Air is admitted by a push-handle throttle, which is opened when the runner presses the drill against the rock, and closed when this pressure is relieved. The hole is cleaned by the exhaust air, which passes through the drill



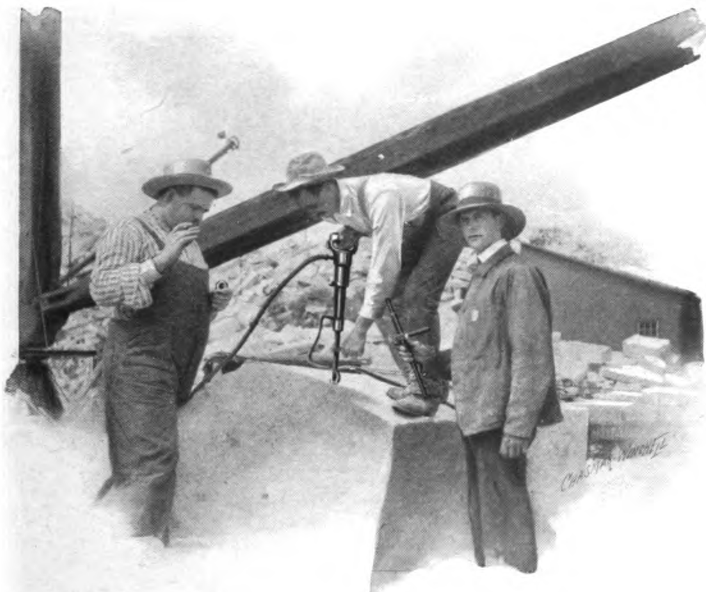
Plan for channeling steps from a granite block.



Special broach.

steel, and is kept true and round by rotating the steel with a hand wrench. The drill steel terminates in a "rose" bit, with from six to eight cutting edges.

This machine recently set a new cutting record for drills of this class, in Barre granite, by drilling a number of holes twelve inches deep and 1¼ inches in diameter, in an average time of one minute and 45 seconds. The best time for a single hole was one minute and 30 seconds. The tool is especially suited for pop or block holes for splitting up large blocks of stone, for shallow channeling, as described above, and quarrying and contract work requiring blasting holes from one to three or four feet in depth.



Sullivan "Plug Drill" on a test run.

AMOUNT OF POWER CONSUMED IN CUTTING COAL.

The amount of power required to cut a given amount of coal is an important consideration in installing a machine mining plant. The actual power consumed by air pick machines in cutting a cubic inch or foot of coal is hard to determine with exactness, owing to pipe line leakages, use of the air for other purposes, fluctuations in steam and air pressure, et cetera. In the case of electric machines, however, portable instruments have been perfected which may be attached to the mining machine itself, and which register the quantity of power consumed with accuracy. By means of a series of readings, the operator may determine just how much power is used by a given type of machine in cutting a given quantity of coal.

There are two distinct classes of electric chain coal cutters in use in this country for room and pillar mines:—The breast machine and the Sullivan "continuous cutting" type. There are several designs of the former, which all work on the same principle. The machine is controlled by front and rear jacks, and is fed under the coal, making a cut from 30 to 42 inches wide and four or 4½ inches high. The machine is then backed out, and barred along the face, by hand, to make a fresh undercut. The jacks must be torn down and reset each time. This process is repeated until the room is crossed. The accompanying sketch (No. 1) shows this method. It may be observed that power is lost each time the machine is backed out from the coal, also in hand-barring, changing of jacks, et cetera, to say nothing of the fact that the second cut must overlap the first sufficiently to prevent the formation of a sprag or rib between the cuts.

The Sullivan machine is practically an adaptation of the long wall principle to room and pillar work. The machine

Sullivan Chain Coal Cutter: completing the "sumping" cut, and detaching pan, or rear half of frame, before cutting across the face.

makes its first or sumping cut against the right hand rib, in the same way as the breast type. A rear, or take-up jack, is then set in the corner, behind the machine, and a front or anchor jack in the left corner of the room. The rear half of the frame is then detached, and the machine propels itself along the face upon a feed chain stretched between these jacks, making a continuous cut under the coal to the full depth of the bar. The machine is not withdrawn from the coal, nor the jacks changed until the left hand rib is reached. The time- and power-economy of this machine over the breast type is self-evident. This method of operation is illustrated by the second sketch, and by the accompanying photographs, showing the Sullivan machine at work.

The table below gives results of several tests recently conducted, with a view to determining the amount of power required to cut a given amount of coal by the Sullivan Electric Room and Pillar Chain Machine, as compared with machines of the ordinary chain breast type.

It may be noted from the table, that while the Sullivan machine was under greater load in each case, owing to the fact that it cut a higher kerf, the number of foot pounds consumed in cutting a cubic inch of coal was very much less.

In the case of the last record, it should be observed that the showing made by the Sullivan machine is in reality much

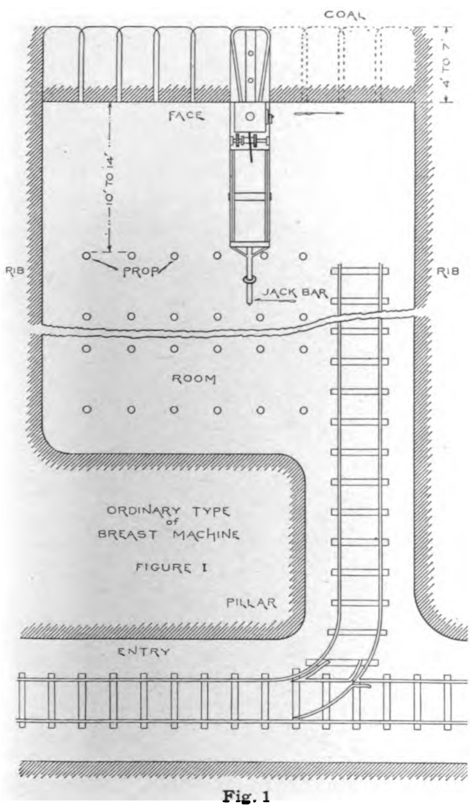


Fig. 1
Room and pillar mining with ordinary breast machine.

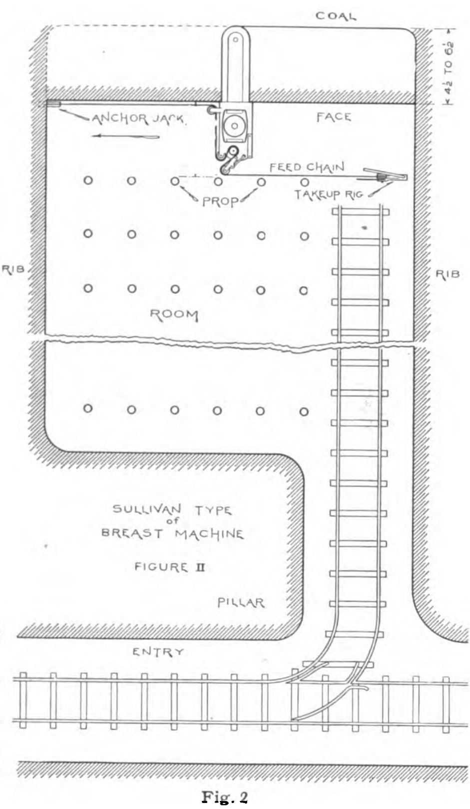


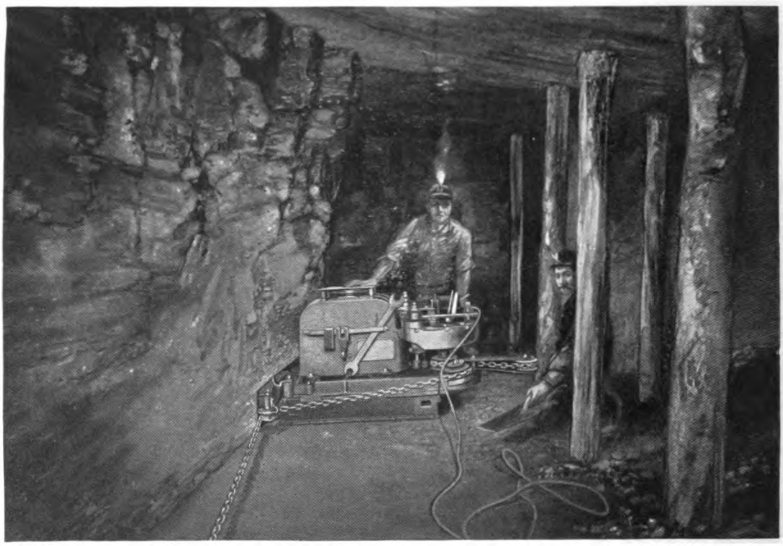
Fig. 2
Room and pillar mining with the Sullivan Chain Machine.

Place	Machine	No. of cuts or width of room	Depth of cut, inches	Width of cut, inches	Height of kerf	Average load H. P.	Ft. lbs. per cu. in. of coal cut	Time for cut, min.	% power saving Sullivan over competitor
Carneyville, Wyo.	Sullivan Breast Type No. 1.	18″ per min. 1 cut	78 84	* 38	6 4	16.8 11.5	65.8 105.79	 3.50	.378
Sturgis, Ky.	Sullivan Breast Type No. 2.	68′10″ 6 cuts	78 60	* 33	5¾ 4	23.5 16	186 431	75 36	.569
Linton, Ind.	Sullivan Breast Type No. 3	30′5″ 5 cuts	66 63	* 29	5¾ 4	16.7 10.75	135 156	33.5	.135

* See Column 8.

more favorable than indicated, since this machine was unloaded, loaded and moved from place to place along the face of the coal under its own power, which was measured and included in calculating the average load. It was not possible to determine these factors for the breast machine tested, so that the power shown is merely that consumed in actually cutting coal. This was also the case in the second test recorded in the table.

The "continuous cutting" type of coal mining machine possesses other important advantages over the chain breast pattern. Since the cutter bar is at all times under the coal, and the pan or rear half of the frame is detached after the sumping cut, the machine occupies from



**Sullivan Coal Mining Machine crossing the face in one operation.
The props shown are only 6 feet from face. They need not be moved to permit the passage of the machine.**

one-half to one-third as much space in front of the coal, as the breast type, while crossing the face. This means that props may be set and maintained much closer to the face, that the gob does not need to be moved so far back, and that loading is quicker and easier. The absence of sprags at the rear of the cut enables the coal to roll out easily, without being shattered by heavy blasts of powder. The roof is not weakened by the line of holes made by the rear jack of the breast machine, and all handling of the machine is done by its own power, eliminating hand labor.

The Sullivan type cuts on the bottom, leaving no coal to be lifted, and cuts parallel with the floor at all times.

THE COST OF DIAMOND DRILLING.

The question of the cost of diamond drilling is naturally of the greatest interest to the mine owner and engineer. The one item which deters those unfamiliar with work of this sort, is that of the cost of "black diamonds" or carbon.

While the price of carbon at the present time is much higher than it was fifteen or twenty years ago, this is due to the fact that the use of diamond drills has rapidly increased of late years, and there are many more drills in operation now than when carbon sold at half the present price. This indicates that the cost for carbon is not a serious item, especially when the rate of progress and the accuracy of the results are considered. Bearing these advantages in mind, diamond drilling is actually the most economical method of prospecting.

A careful record of the cost of drilling, kept by a Michigan iron mining company which uses a number of diamond drills, shows total drilling costs, (including carbon) ranging from $1.50 to $2.00 per foot. A Western coal mining concern places the cost of its extensive diamond drilling operations at one dollar per foot or less. A large number of holes, bored in the Lake Superior iron country, and aggregating over 11,000 feet, showed costs ranging from $1.63 to $2.65 per foot. The cost of carbon in the former item was 19 cents and in the latter, $1.00 per foot, the remainder being due to labor, fuel, superintendence, supplies, et cetera. A Mexican copper mine reports the cost of 4160 feet of diamond drilling as $2.22 per foot, of which $1.03 was due to carbon wear. Eleven hundred feet of drilling in the copper formation of Southeastern Arizona, cost $0.38 per foot for carbon, and $1.35 for labor and all other items. The expense of long continued coal prospecting in various states, is reported as follows:—Colorado, $1.65 per foot; Tennessee, $1.26; Indian Territory, $1.18; West Virginia, $1.13 to $1.50.

As will be noted from these records, the cost of diamond drilling varies within wide limits, depending on local conditions as to labor, fuel, water, superintendence, availability of supplies, living expenses, et cetera. Aside from the differences of formation encountered in drilling, it should be remembered that frequently the cost of two holes, side by side in the same formation, will vary, owing to extraneous or unforeseen circumstances. The *Engineering and Mining Journal* has the following to say on this subject:—

"A recent compilation of statistics with reference to the cost of diamond drilling, goes to prove how variable is the cost of such work, and how utterly impossible it is to fix anything more than general rules from which an approximate figure of cost can be reduced. Out of 20 holes, drilled through jasper, marble, and iron slate, and varying in depth from 110 to 1100 ft., the average cost was $3.14 per ft. Of this cost, 39 per cent. went for labor, 22 per cent. for carbon and the remainder for fuel, repairs, supplies, etc. Another series of 16 holes varying in depth from 94 to 380 ft., with an average of 314 ft., showed an average cost of $2.70 per ft. Of this amount, 38

per cent. went for labor, and 13 per cent. for carbons. The cost of drilling in soft schist rock was as low as $1.00 per ft., of which labor formed 66 per cent. and diamonds 30 per cent. The cost of drilling in hard syenite rock was twice that of drilling in tough diorite, the cost of the diamonds in drilling the syenite rock approximated 63 per cent. and the labor 38 per cent; in the diorite rock the carbon cost 30 per cent. and the labor 66 per cent. of the total. The speed of drilling varied from 6 to 25 ft. per day, and the holes had a mean diameter of 1$\frac{3}{4}$ inches."

The following extracts from an article on Diamond Drilling in the Boundary District (B. C.) will be of interest in this connection, (read by Mr. Frederic Keffer, Manager of the British Columbia Copper Co., Greenwood, B. C., before the Canadian Mining Institute):—

"As an adjunct in prospecting and developing the low-grade ore deposits of the Boundary, the diamond drill has proved an unqualified success. As these great orebodies have been opened up, it has come to be more and more apparent that the ore exists in irregular masses with usually no very well defined walls (except where it lies in contact with limestone). Further the deposits are frequently separated by barren zones, so that when the boundary of an orebody is reached it is quite impossible to predict whether more ore will be found beyond or not. Commercially, the low grade of the ore prohibits crosscuts or drifts being run in barren ground solely in order to prospect it, the only allowable dead work being that necessary to reach known deposits.

"It is under these conditions of necessary economy and uncertainty of ore occurrences that the diamond drill has become so useful, not the least of its value being negative, for knowing where the ore is not to be found is only secondary to finding it.

"Most of the drilling done under the writer's direction has been done by day labor, this having been found to be more

1. PROGRESS TABLE.

	April May	June	July	August	Sept.	Oct.	Nov.	Dec.
Shifts....	37	26	26	27	23	27	26	25
Feet drilled...........	304	253½	259½	295	250	245	278½	356
Hours drill was run ..	231	167	149½	194	164½	142	170	167½
Hours setting diamonds, moving machine, etc	57	44	79½	22	19½	101	38	32½
Feet per shift........	8.21	9.75	6.98	10.93	10.87	9.07	10.71	16.24
Feet per running hour.	1.31	1.52	1.74	1.52	1.52	1.72	1.64	2.13
Carats used..........	6.$\frac{36}{64}$	6.$\frac{55}{64}$	7.$\frac{42}{64}$	5.$\frac{62}{64}$	6.$\frac{47}{64}$	4.$\frac{9}{64}$	7.$\frac{58}{64}$	2.$\frac{8}{64}$

(Note—Underground shifts are 8 hours. Surface shifts 9½ hours.)

2. COST TABLE.

Labor............	403.60	272.00	260.88	271.00	210.35	219.60	226.50	231.75
Diamonds	328.81	342.99	382.81	298.45	299.18	227.73	434.85	114.83
Power, etc...........	13.46	29.10	30.56	26.76	25.13	31.78	18.49	118.97
	745.87	644.09	674.25	596.21	534.66	479.11	679.84	465.55
Feet	304	253.5	259.5	295	250	245	278.5	356
Cost per foot..........	2.45	2.54	2.60	2.02	2.14	1.95	2.44	1.31

satisfactory than contract work, as well as more economical.

"The daily reports are tabulated, and the costs of work figured at the close of each month. Drilling by day labor was started in the mines under the writer's charge last spring, and the following tabulated results (see preceding page) may be useful to those contemplating similar work.

"Total feet drilled during 1905 is 2241.5; average per shift during 1905, 10.32 feet; average cost per foot, $2.1501; average cost diamonds per foot, $1.0830."

PERSONAL.

Mr. Cal Boyer, formerly connected with the Criterion Mining Co., at Porto Rico, Mo., is now superintendent of the Talisman Mining Co., north of Carterville, Mo.

Mr. Harris, formerly of Rich & Harris, is now a member of the firm of McCabe & Bihler, railroad contractors, Providence, R. I., and Bristol, Conn.

The present address of Andrew B. Crichton, Mining Engineer, is 513 Lincoln Bldg., Johnstown, Pa. Mr. Crichton has been at Beaverdale, Pa., until recently.

James Christman is now superintendent of the Criterion mine at Porto Rico, Mo. Until recently, Mr. Christman has been in charge of the Teddy R. Mine, Alba, Mo.

Mr. W. L. Cumings, Mechanical Engineer of the Bethlehem Steel Co., at So. Bethlehem, Pa., has accepted a position with the Juragua Iron Co., Santiago de Cuba.

John C. Reid, for a number of years general superintendent of the Great Western Coal & Coke Co., McAlester, Indian Territory, has been appointed to the position of general manager.

F. McDonald, formerly superintendent of the Commercial Mine at Bingham, Utah, is now superintendent of the Ohio Copper Co., at Bingham. Mr. J. Highland, formerly of the Utah Copper Co. has taken his position at the Commercial.

Mr. S. S. Arentz is superintendent of the Nevada-Douglas property at Yerington, Nevada. G. T. Bean, foreman of the Minnie Mine of the Utah Apex Mining Co., Bingham, Utah, has been transferred to the Nevada-Douglas, which is controlled by the same interests

Thomas F. M. Fitzgerald, for several years general manager of the Federal Lead Co., Flat River, Mo., resigned on February 1, being succeeded by Edmund S. Kirby. Mr. Fitzgerald will remain at Flat River for the present, looking after personal business.

Mr. D. F. Haley resigned his position as superintendent of the North American Lead Co., Fredericktown, Mo., several months ago, to assume charge of new mining operations in Canada. Mail addressed to him at Ste. Genevieve, Mo., will be forwarded.

R. H. Channing, Jr., left Salt Lake City the latter part of January, for Peru, where he is to be manager of the Cerro de Pasco Mines. His position as general manager of the Utah Consolidated M. & M. Co. has been filled by the appointment of J. D. Risque, formerly a prominent Montana manager.

R. B. Hutchinson, recently with the Compania Beneficiadora Concheno, at Concheno, Sonora, Mexico, has left there, as the property has been sold to the Greene Gold-Silver Company. After a visit to the United States, he will open an office as consulting engineer and metallurgist in the City of Mexico.

Mr. H. Roskelly, formerly in charge of Lane Bros. Co.'s three Sullivan air compres ors at Eggleston, Va., has been appointed mechanical superintendent for A. E. Elevier, who has a contract under Russel & Oliver to d ive the Southern Railroad's double track tunnel at Lynchburg, Va. A Sullivan Compressor is being erected to supply air to the drills and steam shovel to be used in this work.

MINE AND QVARRY

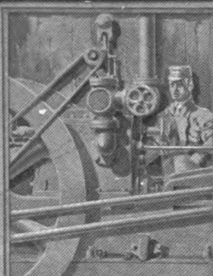
VOL. II. NO. 1. MAY, 1907

SULLIVAN ELECTRIC COAL MINING MACHINE AT WORK, BICKNELL, INDIANA

THE PANAMA CANAL IN APRIL 1907

WESTERN PRACTICE IN TUNNEL DRIVING

ECONOMY IN QUARRYING SLATE



PVBLISHED BY THE SVLLIVAN MACHINERY CO. RAILWAY EXCHANGE BVILDING, CHICAGO.

TABLE OF CONTENTS

Editorial 113

The Panama Canal in April, 1907 114

Photographing a Mine Explosion 117

Western Practice in Tunnel Driving . . . 118

Economy in Quarrying Slate 123

Coal Mining at Bicknell, Indiana 129

Mineral Prospecting at Cobalt 137

MINE AND QUARRY

Vol. II. No. I. MAY, 1907

A Quarterly Bulletin of News for Superintendents, Managers, Engineers and Contractors.

Published by the Advertising Department of the Sullivan Machinery Company.

Address all Communications to MINE AND QUARRY, Railway Exchange, Chicago. Sent to any address upon request.

Readers are requested to notify MINE AND QUARRY of any correction or change in address.

Economy of natural resources is comparatively a new study to the American people. The wealth of the country has seemed without limit to the miner, the lumberman and the stonecutter, but the present generation, with its larger industrial demands for material of all kinds, has brought realization of the havoc caused by wasteful methods. The old conditions and the new are well exemplified in the slate industry. The piles of waste rock surrounding the older pits represent a dead loss of many thousands of dollars. In striking contrast are the newer quarries, from which practically all the stone taken serves a useful purpose. An article describing the methods which have caused this change will be found in another column.

The Cobalt, Ontario, district, with the almost fabulous richness of its surface showings, is just now the Mecca of the unsystematic prospector and of the wildcat mining promoter. That the region will become a large and permanent producer, no one doubts. A word of warning may, however, properly be spoken at this time. Not all Cobalt claims will make millionaires of their owners, nor will all scratches on the surface become shipping mines. Conservatism points to thorough testing at depth before development, for the sake of accurate knowledge and of economy. A set of diamond drill cores is the soundest and most convincing argument which can be used to assure investors of the worth of a mining proposition. An article on this subject will be found in this number.

Methods of driving tunnels for mining or engineering purposes vary, in important particulars, in different sections of the country. The article on the Ophelia Tunnel, in the Cripple Creek district of Colorado, published elsewhere in this issue, describes the best western practice in hard rock tunneling. As evidence of this it may be stated that this tunnel has been advanced more rapidly than any other working of equivalent size in this district. The principle adopted, that of keeping the men and equipment constantly at work, is generally recognized as productive of lowest operating expense.

In subsequent issues, usage in tunnel driving in other parts of the country will be described. The reader is referred to an article in the August, 1906, issue, on the Gunnison Irrigation Tunnel, and to one in the November number of that year, describing tunneling methods used on the Tidewater Railway in Virginia.

Cutting through the hill at Culebra.

THE PANAMA CANAL IN APRIL, 1907.

WRITTEN FOR "MINE AND QUARRY"

BY ROY D. HUNTER.*

If any doubt existed in the mind of a visitor to the canal, early last April, as to its completion, this doubt was quickly dispelled. The long procession of dirt trains moving rapidly towards the dumps had a very business-like aspect, and to see them loaded by the great steam shovels was fascinating and inspiring. The problem of the canal has in reality resolved itself into a question of removing rock and earth, one with which American contractors are too familiar to consider formidable.

When President Roosevelt visited the Isthmus, last November, he congratulated his country because the rate of excavation was then exceeding the best which the French had done. In that month about 422,000 yards were removed. In March of this year, 815,000 yards of material were removed, and in April, 879,500 yards. On April third, 37,440 yards were removed, one steam shovel handling 2,600 cubic yards in a single day of that week. On May 1st, about 51,000,000 yards remained to be excavated. It is expected that a rate of 1,000,000 cubic yards per month will be attained during the dry season, and that this rate will not be materially decreased during the rainy months. The date at which the canal will be completed is, therefore, hardly a problem in long division.

Preparation for work on such a scale is a task realized perhaps only by those who have undertaken large work at a great distance from supplies, and in an unhealthy climate. Much has been written on the efficient work of sanitation, and of the other features of creating living conditions for Americans upon the Isthmus, so that mention of these matters is unnecessary here.

In brief, the canal consists of a rock and earth cut nine and one-half miles

*Railway Exchange, Chicago.

The Canal in December, 1906, looking south from Cunett.
(Photo by Fishbaugh)

long, known as the Culebra division, with a lake at either end, 85 feet above sea level. These lakes are reached by locks and earth canals, leading to the Atlantic and Pacific Oceans respectively.

The great earth dams to be constructed at Gatun, Mira Flores and La Boca, for the purpose of forming these lakes, together with the locks at these points, will be extremely interesting undertakings. This work has been begun and will be advanced rapidly from this time.

The Culebra division is at present the center of the most active operations. The material to be excavated here varies from sandy soil to hard trap rock. Fifty-three steam shovels, principally of the 95-ton class, with five-yard dippers, are employed in this division. The sand and gravel is excavated directly by the shovels, but the rock is first drilled and blasted into fragments small enough to be conveniently handled by the dippers. The spoil is loaded into cars of two classes. On long hauls, flat cars of the ordinary pattern are employed, having side boards on one side, and connected or vestibuled to each other by aprons or sheets. These cars are unloaded by a plow, hauled from one end of the train to the other, by means of cables running over a drum carried in the car next the engine. For short hauls dump cars with tilting bodies are used. In excavating rock the customary bench method is used, the nominal height being 30 feet, and width 35 feet. Churn drills are largely used for the vertical blast holes, and in some cases have put in holes up to 80 feet in depth, on the top benches, where required by the contour of the hill. Five 80-foot drill holes in the Bas Obispo cut, referred to below, were shot with seven and one-half tons of black powder, producing over 37,000 yards of spoil. Rock drills are employed for drilling flat or horizontal holes under the benches to a depth of about 20 feet. There is also much vertical drilling done by these machines, where the conditions make 20-foot benches advantageous. The blast holes are sprung from one to three times by

Sullivan Rock Drills at work in the Bas Obispo Cut.

charges of increasing strength until a chamber is formed which will hold a sufficiently heavy charge to shatter the rock. Both black powder and dynamite are used, the latter being about 35 per cent. grade. The rock varies from solid tough trap to soft spongy ground, so that the shooting problem calls for careful and constant study.

The heaviest rock excavation on the canal is in progress at the northern end of the Culebra division, in the Bas Obispo cut, which is about one and one-half miles long. The formation here is solid, and consists of a tough, close-grained trap-like rock, requiring very thorough drilling and blasting in order to prepare it for removal by the steam shovels. A quarry is located here, for getting out rock ballast for the railroad, and a portion of the rock from the excavation is also used for this purpose, going to the crushers instead of to the dumps.

The French left a heavy natural wall of rock on the Atlantic side of the hill, with the intention of impounding a lake and of employing floating dredges to excavate this part of the canal.

The present plan consists in ordinary drill and shovel excavation, by means of standard bench work, described above. Six steam shovels are employed in this portion of the work. Twenty-five Sullivan rock drills are used for the blast holes, and also a number of churn drills.

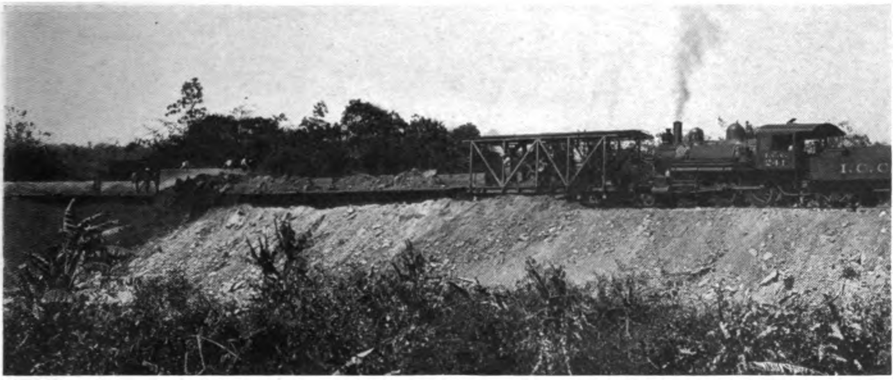
The rock drills put down two 20 to 27-foot holes per day. These drills were installed in 1905, and the accompanying photograph, taken during the President's visit, shows a group of them at work.

More work has been done by rock drills at this point than in other parts of the division, owing to the fact that they have been at work longer and have had harder rock to deal with. These drills are operated by negroes and Spaniards, under the direction of American foremen, each of whom has six to eight drills in

charge. Considering the class of labor, the drilling records are creditable, and the excellence of the machines is attested by the small amount of repairs that has been used.

The drills were at first run by steam, but in the fall of 1906 three air power plants, one each at Las Cascadas, Empire, and Rio Grande, were placed in commission, and all classes of drills are now operated by compressed air. The air is distributed by a ten-inch main, which runs almost the entire length of the division, and by four-inch branch pipes.

The engineering, superintending, accounting, disbursing and commissary management of the canal is composed of Americans. The visitor to the isthmus is received with a cordial hospitality which makes his stay one to be pleasantly remembered, while he is strongly impressed with the high order of intelligence and the engineering and executive ability of the men who are doing the work.



A spoil train at the dump, showing the unloading plow at work. (Photo by Fishbaugh)

PHOTOGRAPHING A MINE EXPLOSION.

The accompanying photograph is the external evidence of a very severe colliery explosion which occurred last spring at the Stanford Merthyr Colliery near Newcastle, N. S. W. Two explosions occurred. The first in a tunnel, marked by the small column of smoke at the right. The photographer set his camera to photograph this smoke, when the second explosion in the incline tunnel at the left occurred, at just the right moment to be caught by the camera.

It is supposed that the cause of the explosion was due to a fire in the loose coal at the bottom of the slope, started by a burning lamp wick or a miner's pipe. Fire walls on the slope confined the fire, but also forced unconsumed gases back into the burning district, where they exploded. The chairman of the board of directors of the colliery and several other persons met death in this explosion. The electrical expert of the Australian General Electric Co. had a narrow escape. He was in the mine at the time, in charge of the seven Sullivan electric long wall machines with which this mine is equipped.

Unique Picture oi a Mine Explosion.

Sullivan Air Drills in the Ophelia Tunnel.

WESTERN PRACTICE IN TUNNEL-DRIVING.

WRITTEN FOR "MINE AND QUARRY"

BY W. P. J. DINSMOOR.*

Tunnel-driving in rock formation has developed various methods of procedure, all of which have their good points and champions. Mining tunnels are driven for various purposes, namely, the cutting of ore bodies at depth, the drainage of previously developed mines, and to provide means for the transportation of ore and waste from mines, without the necessity of costly hoisting. The points to be striven for in driving a tunnel are rapidity of advance, and low cost of work. In order to reduce cost, rapid driving is one of the essential points, within limits; these limits being fixed by the initial cost of the plant; the daily cost of operating the plant; the purchasing of supplies; the cost of labor and the cost of handling "muck" or broken rock.

Assuming that the required plant is decided upon and bought, economy would seem to dictate that this plant should be kept running under as nearly a constant load as possible. This means the equal distribution of work through as large as possible a part of the day and of the month as conditions will allow. Interest on the purchase price of the equipment goes on whether the plant is actively in operation or not, and when the plant is idle for part of the day, fires must be kept under boilers, and a fireman kept on duty to care for them.

THE OPHELIA TUNNEL.

The Ophelia Tunnel in the Cripple Creek District of Colorado was driven for the purpose of draining mines, and transporting ore and waste from the deep levels of such properties as it might cut. The methods employed in advanc-

*1748 Broadway, Denver, Colo.

ing this tunnel are by no means unknown to many people interested in this form of operation; nevertheless they may prove of interest to those unacquainted with the methods adopted in this instance, and also, perhaps, to those to whom this is a twice- or often-told tale.

This tunnel has been driven to a point approximately 8500 feet in a direct line from its portal. It is for its entire length nine feet by nine feet in the clear, and in places will show ten feet by twelve feet.

The tunnel was driven through granite, then into breccia, with intervening dykes of phonolite, andesite, and nephaline basalt, at an average rate of 350 to 375 feet per month. 350 feet per month was considered low, and such a result called for investigation by the management of the causes which reduced the work accomplished to this figure. The record month showed an advance of 395 feet and 8 inches. This speed in driving was obtained by careful planning of the work, so there would be no loss of time or idleness for either the men or equipment. This required a thorough study of the conditions that were to be met and overcome, and careful oversight to see that the plans adopted were carried out. The plant used on this work consisted of two 60-horse power boilers; one straight-line, two-stage air compressor; one high-pressure, three-stage, locomotive-charging compressor; one compressed-air locomotive and Sullivan "Class UE-2," 3-1-8 inch drills.

The working day was divided into three shifts of eight hours each.

PLAN OF WORK.

In the actual tunnel-driving work, there were seven men to a shift; two machine drillmen, two machine helpers and three "muckers." Each shift was supposed to drill, load and shoot a round of from eighteen to twenty-two holes, drilled from 5½ to 7 feet in depth, as well as to load the "muck" resulting from the work of the previous shift into the cars, and deliver the cars to the compressed-air haulage engine. The management feels that under the three-shift plan the men do better work and take more pride in its results, owing to the fact that the men know that another shift is following close on their heels to perform the same operations that they have performed, and that the following shift depends upon the satisfactory completion of this shift's work for the accomplishment of their own.

The method pursued was essentially as follows:—

As soon as the smoke resulting from the shooting done by the previous shift was cleared, the new shift of drillmen, helpers and "muckers" all went to work, and the broken rock from the face was thrown back sufficiently to allow the columns for mounting the drills to be put in place. The two drillmen worked together, and the two helpers worked together in pairs, relieving each other at intervals; the "muckers" going immediately to work, getting the "muck" into the cars and on its way to the dump. When the helpers were working on the muck pile, the drillmen were back of the

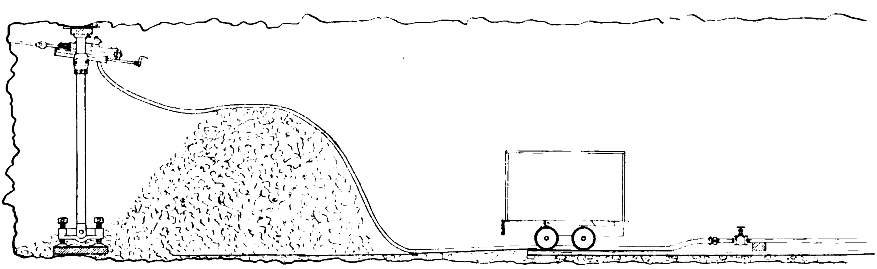


Figure 1.

work; looking up equipment; seeing that all the machine drills, steel, hose, tools, blocking, etc., that would be required for the shift's work were on hand, and, if anything was found missing, taking steps to secure it. When the drillmen were working on the muck pile, the helpers were employed in bringing the required material up to the face, where it would be readily available.

It may be objected that this would be possible only in a short tunnel, but in this tunnel, about one and two-thirds miles long, this work was accomplished by each shift every day. As soon as the muck was cleared away from the face, the columns were put in place; the drills mounted, and the drilling of the new round commenced.

In clearing away the muck, care was taken that it should not fall back toward the face until a sufficient space was provided in which to set the columns. After the columns were set, the muck was allowed, and in fact encouraged, to fall back, until it had filled the space in front of the face up to such a level that the tops of the jack screws of the columns could just be reached. By this method, the back holes, or those nearest the top of the tunnel, were the first to be drilled, and the drillmen and helpers worked from the top of the muck pile. This did away with any form of staging, and while the drillmen worked towards the bottom of the tunnel, the muckers were removing the pile, thus always giving the drillmen a standing ground of proper height, or really a self-adjusting platform, much wider and more solid than any portable timber staging. It was of course necessary for the muckers to finish loading out the muck before the drillmen reached the bottom holes or "lifters," but they did not stop work until the end of the shift was reached, as there was rail laying, and the placing of sheets, to occupy their attention until the holes were loaded and ready for

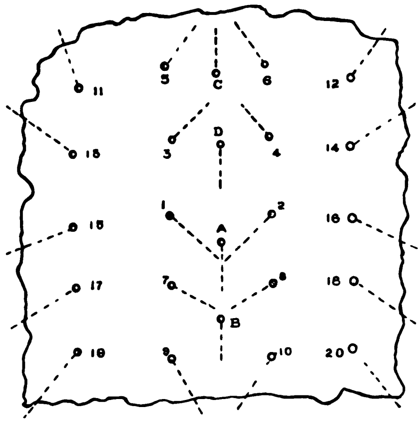


Figure 2

shooting. Everyone on the shift was busy from the time he reached the heading until the holes were loaded and fuses spit. The only time lost in the 24 hours of the day was that required for changing shifts and the clearing of powder smoke.

Full length mining columns were used, in order to reduce the amount of blocking needed at the top and bottom of the columns, and to insure the removal of the muck from the face, clear to the bottom of the tunnel before the set-up, so that resetting would not be required when the bottom holes were reached.

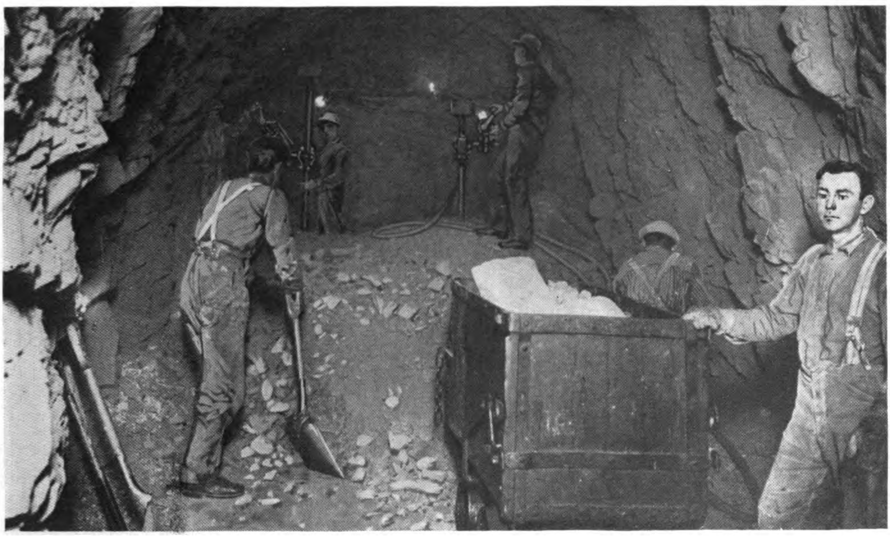
Care was always taken to see that the men were well supplied with all material for their work. Empty cars were always kept at the face; an extra machine drill was constantly on hand, so that if one of the drills in use required repairs, it could be laid aside, to be put in order by a skilled mechanic. Thus the drillman and his helper were not delayed by making repairs. Plenty of sharp drill steel and water for use in the holes were kept close to the face.

ARRANGEMENT OF DRILL HOLES.

The important matter of properly placing and shooting drill holes was carried on as follows:— In Figure No. 2, holes Nos. 1 and 2 are cut holes. These were drilled from six to seven feet

deep, looking down, and were so placed and directed that their inner ends nearly met. The fuse for these holes was so cut that they were fired first and nearly at the same moment. Holes Nos. 3 and 4 are cut holes, drilled looking up and about the same depth as Nos. 1 and 2. They were so directed that their inner ends did not meet, as in the case of Nos. 1 and 2. The fuse was so adjusted that these holes were fired just after Nos. 1 and 2. Holes Nos. 5 and 6 are the back cut holes. They were drilled looking up, and so directed that their inner ends did not meet, nor did they extend beyond the top of the tunnel. These holes were shot together and just after Nos. 3 and 4. Cut holes Nos. 7 and 8 look down, and were timed to shoot after Nos. 5 and 6. Holes Nos. 9 and 10, the cut lifters, look down and extend below the proposed bottom of the tunnel. Holes Nos. 11 and 12, the back rib holes, and holes Nos. 13 and 14, rib holes, look up. Holes Nos. 15 and 16, also Nos. 17 and 18, rib holes, and holes Nos. 19 and 20, rib lifters, all look down and all extend beyond the line of the side walls, and were all shot at nearly the same time.

Where stiff ground was encountered holes A and B were put in, and shot with holes Nos. 1 and 2 and Nos. 7 and 8 respectively. Where very stiff ground was found, holes C and D were added and shot with holes Nos. 5 and 6 and Nos. 3 and 4 respectively. By analyzing the above it will be found that holes Nos. 1 and 2 take out or loosen a wedge-shaped portion of the rock, thus relieving the resistance to the action of the powder in holes Nos. 3 and 4 and holes Nos. 7 and 8. Holes Nos. 3 and 4 and Nos. 7 and 8 clear the way for holes Nos. 5 and 6 and Nos. 9 and 10. Holes Nos. 9 and 10 have a tendency to throw any broken rock above them out of the way of the remaining rib holes. Holes A, B, C and D serve simply to increase the effect of the holes with which they are shot. By placing the holes in this way and shooting in this order, the break, with very few exceptions, always cleared the rock for the full width and depth of the tunnel, thus doing away with the necessity of following the heading with any work designed to break off projections.



The heading showing muck pile, car and sheets, Ophelia Tunnel.

Tamping material for use in the loading of the holes was always employed. It was found that by using this, the results obtained were most satisfactory, and that less powder was consumed.

HANDLING THE MUCK.

Two tracks were maintained close to the heading. Before the shots were fired, steel sheets were placed on the floor close to the face, extending back far enough to receive all the broken rock. It was found important to have these sheets weighted, and enough muck was kept at the face to do this properly. The sheets formed a smooth floor from which to shovel the muck, but unless the sheets were weighted, it was found that the vacuum created by heavy shots was likely to lift them and mix them with the muck, thus not only defeating the purpose for which they were intended, but actually increasing the labor of mucking. The sheets behind the main portion of the muck pile served to receive part of the muck thrown from the face, and also to facilitate the handling of cars.

A convenience for saving time was the use of a flanged valve on the heading end of the pipe line, instead of the screw valve commonly employed. There was also a telephone system, one station of which was kept well up toward the heading. In case of accident, or when it was necessary to communicate with the portal or power house, the use of the telephone saved valuable time.

VENTILATION.

The removal of powder smoke after shooting was accomplished by means of a blower and the compressed air system. As soon as the work of drilling stopped, the engineer would notice the fact that the demand for compressed air had ceased; he would then fill the receivers and pipe lines with air at 100 pounds pressure. After the holes were loaded and fuses spit, the drillmen would open the gate valve at the heading, allowing a full stream of air under 100 pounds pressure to play on the face through a one-inch whistle cock. This volume of air, coming with a high velocity, stirred up the smoke and mixed thoroughly with it. The pressure in the pipe lines dropped rapidly, and as soon as the pressure reached 20 pounds the engineer started the compressor and kept the pressure at this point, and also started the blower, if it was not already running. A 15-inch ventilating pipe was used and the smoke was soon thoroughly mixed with fresh air. It was seldom that men could not get to the face 20 minutes after the shots were fired.

It will be seen that every endeavor was made to save time, and that, these efforts being successful, there was a consequent reduction in cost. For varirious reasons the figures showing the cost per foot for this tunnel cannot be given, but figures shown by the management of this tunnel, compared with figures of the managers of other tunnels, driven under similar conditions of ground, cost of labor, fuel, powder, etc., show the cost of this tunnel to have been very low. The men were well paid, but no bonus was given for progress above the average rate per month. The work was done thoroughly; the alignment and grade of the tunnel were kept perfect, and it would seem reasonable that the methods employed in driving the tunnel were responsible for its rapid headway and low cost per foot.

Acknowledgments are made to Mr. J. M. Parfet for information upon which this article is based.

A typical quarry in the Pennsylvania slate region.

ECONOMY IN QUARRYING SLATE.

By Arthur E. Blackwood, M. E. *

One of the principal slate districts of America lies within the boundaries of Northampton County, Pennsylvania, and its immediate vicinity, in the towns of Pen Argyl, Slatington, the Bangors, etc.

The visitor to these slate quarries is deeply impressed by the immense amount of waste slate piled up in the immediate vicinity of every opening, covering large tracts of valuable slate property, and naturally wonders why so much slate has been broken up and thrown away.

These monuments of waste material mean not only the loss of the slate itself, but also an expenditure of about 40 cents per cubic yard to remove it from the quarry to the dump pile; so that, could the slate have been used for commercial purposes, there would have been a great saving to the operator.

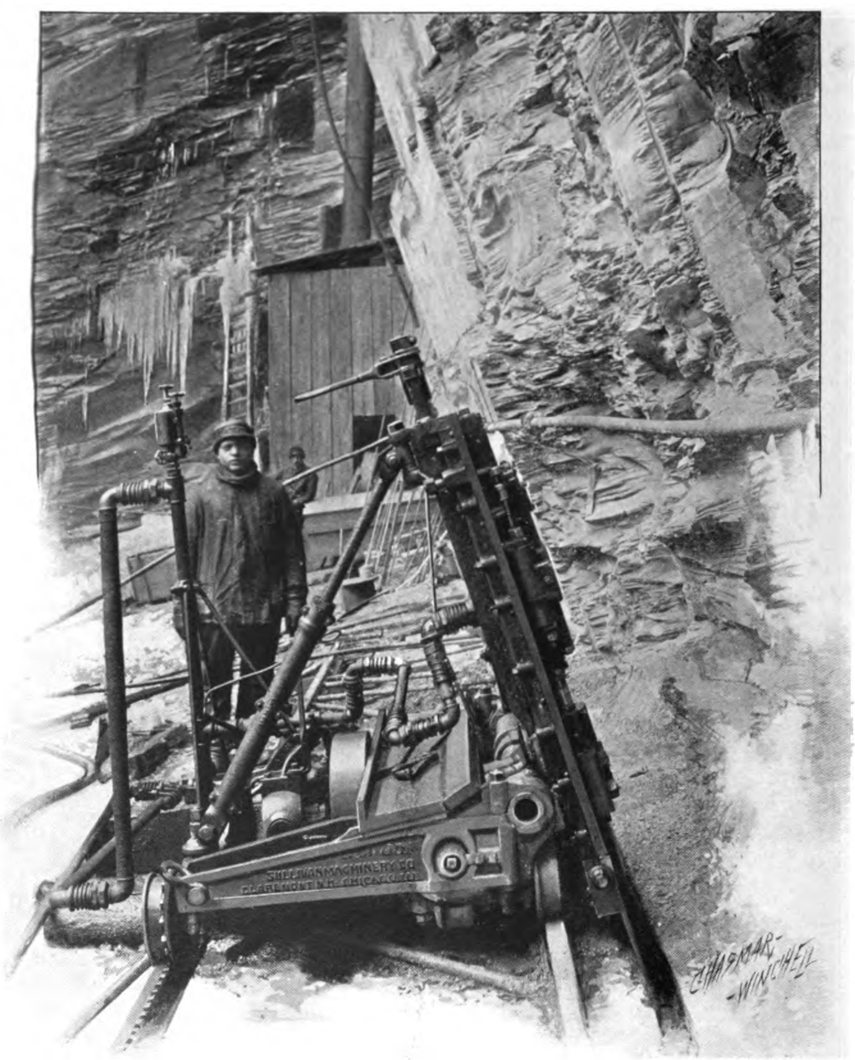
* 42 Broadway, New York.

EARLY METHODS.

Many of the slate quarries have been in operation for years, and were opened up long before the machinery of to-day was even thought of, consequently the slate beds had to be loosened with powder, the only means of doing the work at that time.

In opening up or loosening a new bed, it is first of all necessary to make a sink, which is an opening about twenty feet square by ten feet deep, at one of the corners of the back end of the quarry. The water in the quarry drains into this sink or well, whence it is pumped to the surface.

The bed of slate has then to be loosened along the back end and up one side along the scallop, which with the old or powder method meant drilling and blasting, with resultant damage to the slate for about 20 feet in from the quarry walls. The



Sullivan "VX" Channeler in quarry of Excelsior Slate Company, Pen Argyl, Pa.

other end and side of the bed could then be broken away with less damage, and the injury would not extend back more than ten feet from the walls.

As an illustration of the loss due to this old method of working the quarries, the following figures have been compiled upon an opening 100 feet by 100 feet, the bed of slate being ten feet thick. In loosening up this bed there would be 51,000 cubic feet of slate blasted out. Under the most favorable conditions, four-fifths of this could be used, so that the damaged or ruined material was about 10,200 cubic feet. The value of slate varies from seven cents to 14 cents per square foot, one inch thick, or from 84 cents to $1.68 per cubic foot, so that the loss on 10,200 cubic feet would be $12,852.00, plus the cost of removal from the quarry to the dump, .40x10,200, equals $151.00, or a total of $13,003.00.

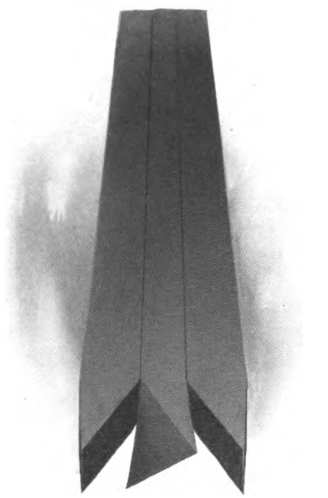
About twenty years ago the bar channeler was first introduced, and the quarry men realized the importance of using this machine to loosen up the bed, by cutting a channel along the back and up one side. But channeling with this machine was a slow operation and it was impossible to keep up with the demand for slate from the dressing shanties, so that much powder had still to be used, and the saving was not as great as it might have been.

ADOPTION OF TRACK CHANNELERS.

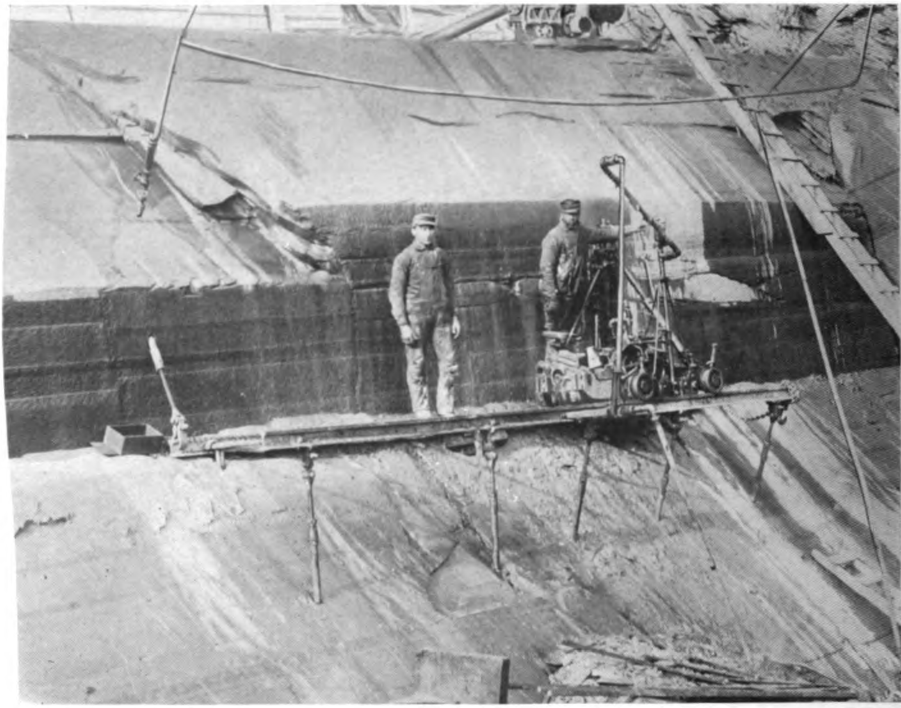
Ten years ago these matters were brought to the attention of the Sullivan Machinery Company, and their engineers set about designing a machine to channel more rapidly than the bar channeler. They decided upon a light track channeler. When the first machine was sent out, many objections were made to the track, but after a short trial, the new machine was pronounced a great success, and the operators found they could use the track channeler in many places where the bar could not be set up. In addition to this, the Sullivan machine was found to be much more rapid in its cutting than the machines formerly used.

The beds of slate in these quarries pitch at angles varying from the horizontal to nearly vertical, and in no two are the conditions exactly alike. In the Slatington region, the beds of slate stand nearly on edge, but at Pen Argyl, and in other portions of the district, from 15 to 45 degrees is the extent of the slope. The class VX channeler was accordingly designed for work upon beds of the latter inclination. The inner edge of one rail of the track on which this machine runs is provided with a machine-cut rack which is engaged by heavy gears cast on the trucks of the machine. By this means the channeler will run evenly while cutting at full speed up or down nearly any grade which may be encountered. Upon the steeper slopes, a counterbalance is employed, attached to the channeler by a rope which runs over a sheave at the top of the quarry, to prevent the machine from running away in case of accident to the friction clutches in the driving mechanism.

This channeler will cut to a depth of ten feet, if desired, and the chopping engine may be inclined at any angle, in order to run a channel 'up to a side wall, to cut



"VX" Channeler Bit.



A "VX" Channeler "cutting the back," Crown Slate Co., Pen Argyl, Pa.

out corners or for undercutting. The three-piece gang bit is commonly used, as illustrated in the cut on page 125. Occasionally the center chisel bit is replaced by a cross bit, but this does not cut as rapidly as the "Z" gang. Practice in sharpening these bits differs in individual quarries, but the illustration above referred to shows the ordinary method. The gauge for starting a nine-foot cut is about three inches. The "VX" channeler weighs 1800 pounds, stands five and one-half feet high on its rails, and runs on a track of 39½-inch gauge.

The channelers in this district are operated by steam. The boiler is ordinarily placed in the quarry as close as possible to the channeler, providing a steam pressure of 100 to 125 pounds. The length of run made by the machines without shifting the track is about 15 feet.

ECONOMY OF CHANNELING.

Since the introduction of the Sullivan slate channeler, it has been adopted by nearly all the large quarries in the Pennsylvania slate district, and instead of channeling the back and one side only, the quarrymen are rapidly coming to appreciate the great economy of channeling both ends and the two sides, thus using the machines to free the bed all around, using no powder except for the scallop holes. The powder bills per month in the old days amounted to $50.00, as compared with $5.00 at the present time.

The cutting capacity of the Sullivan latest improved slate channeler, class "VX," averages from 40 to 70 square feet per day, depending upon the hardness of the slate. On a basis of 40 square feet, figuring the cost of operating the ma-

A Sullivan Drill sinking a "scallop hole."

chine at $9.00 per day the total cost of channeling ten feet deep all around a quarry 100 feet by 100 feet would be $900.00.

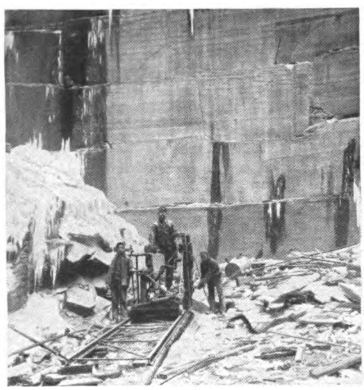
As there is no damage to the slate, there would be a net saving in every ten-foot bed, by the channeling, or present method of quarrying, over the old powder method, of $13,003.00 less the cost of the channeling, namely $900.00, which leaves $12,103.00, or enough to pay for eight machines of the latest improved type.

Outside of the saving to the quarrymen, a source of danger and possible expense is eliminated by the use of channelers, as the walls of the quarry are left strong and solid, and not broken and liable to cave as was the case before these machines were adopted. The photograph on page 123 shows the condition of the walls before channeling was adopted, and that opposite gives a good idea of the solid smooth wall left by the channeler.

REMOVING THE SLATE.

After the beds of slate have been separated from the side walls, the stone is split into blocks. In the larger quarries, cross channels are run with the channeling machines, to reduce the length of the blocks to 50 feet or less. A single "scallop" hole is then drilled to the split, and the block split off "along the scallop" by means of a charge of quick powder, which fills the hole to within six inches of the top. These holes are as small as they can be drilled, usually about one inch in diameter, and are put down with Sullivan 2¾-inch class "UC" steam drills, which are especially designed for work in the slate formation. But one hole is necessary to split the block for its entire length. The blocks are raised from the quarry floor by driving wedges into the split. In case the bed is over nine or ten feet deep, as frequently happens, holes three or four feet in depth are drilled horizontally and a split made by exploding light charges of powder in them. These blocks range in length from 15 to 50 feet, are from eight to 12 feet wide, and from five to ten feet thick. The blocks are then broken up into pieces which may be conveniently handled by rope cable-ways. These cable-ways carry the slate to the shanties, where it is split up into roofing slates, or to the mills, where it is sawed into slabs for structural purposes.

In the Slatington region, referred to above, the slate stands almost vertically

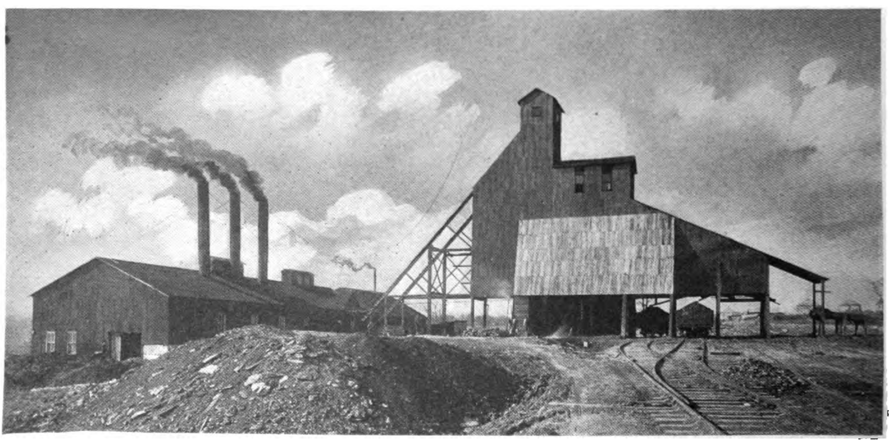


Sullivan "VX" in Jackson Bros.' quarry, Pen Argyl, Pa

and is excavated by means of Sullivan quarry bars, upon which two drills are mounted. These machines put in a series of holes as near to one another as they can be drilled, and at right angles to the beds. A channel is then made by broaching out the walls or cores between the holes, thus loosening the bed. Channelers have been used to some extent in this field for undercutting at right angles to the beds, and have proven economical for this purpose.

The channeler has done much for the slate quarry owners, and is now considered an absolute necessity for the successful carrying on of their business.

The Linn Coal Co.'s Mine, Bicknell, Indiana.



Chicago and Big Muddy Coal and Coke Co.

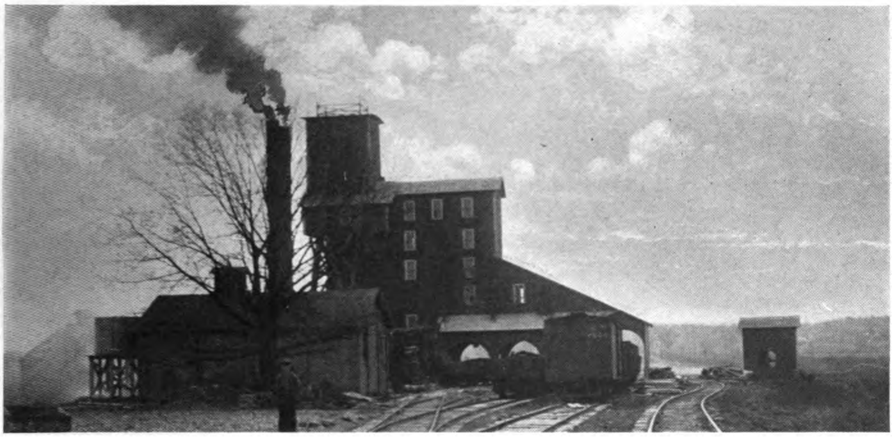
COAL MINING AT BICKNELL, INDIANA.

By M. C. Mitchell.*

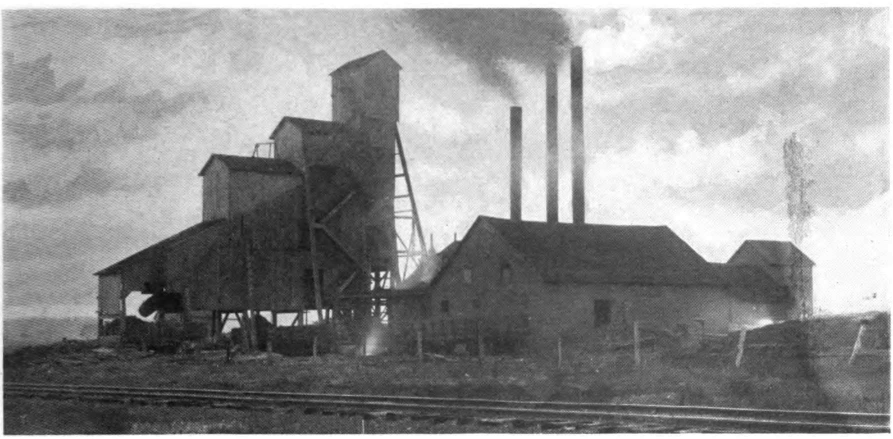
One of the newer Indiana coal districts, which has hitherto been a small producer, but is now being developed to a considerable degree, is that at Bicknell, Knox Co., Ind., on the Indianapolis and Vincennes Railway, about 15 miles due northeast of Vincennes.

In 1901 the coal production in Knox County was 94,579 short tons; 1902, 119,225 short tons; 1903, 177,046 short tons; while in 1905, the last year recorded, the production was 223,964 short tons. This production will probably be doubled during the current year. Prior to 1904 all work done in this vicinity was by hand. About that time, however, the operators began to install mining machines, and the increase in tonnage is largely accounted for by their use.

The coal at Bicknell is mined in two seams, the No. 6, 100 feet below the surface, and the No. 5, 100 feet below

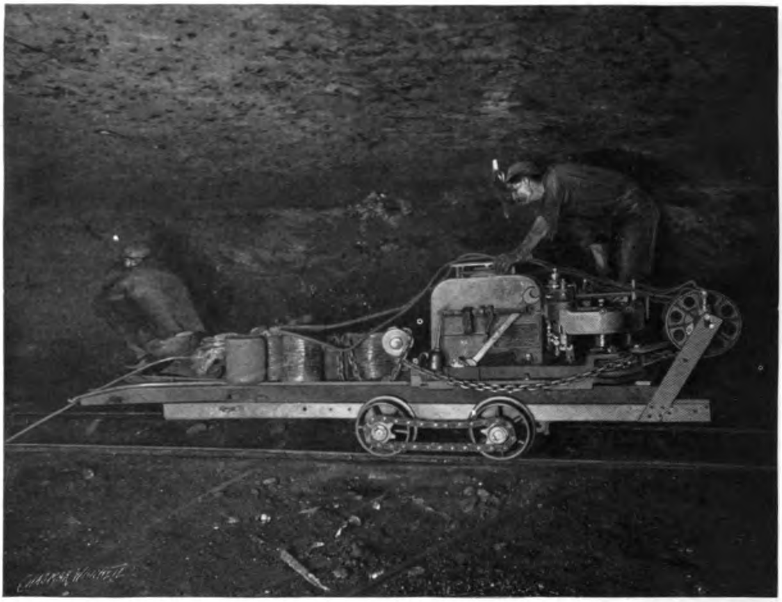


Freeman Coal Co.



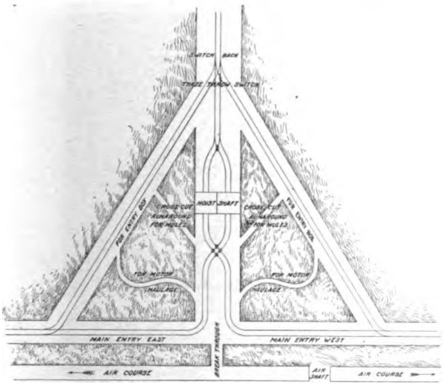
Knox Coal Co.

* Mo. Trust Bldg., St. Louis.



The Sullivan Electric Mining Machine on power truck, en route to a working place.

Unloading in the room from power truck



Linn mine, arrangement of bottom.

the No. 6. The formation is the characteristic southern Indiana and Illinois limestone and shale. The No. 6 seam, in which all of the earlier work was done, ranges from five to six feet in thickness, while the No. 5, which has only recently been opened up, and for which the No. 6 has been abandoned, is from six to eight and one-half feet thick. The coal is of a good grade, showing from 50 to 60 per cent. fixed carbon, and is used both for steaming and domestic purposes, in sizes ranging from five-inch lump to screenings.

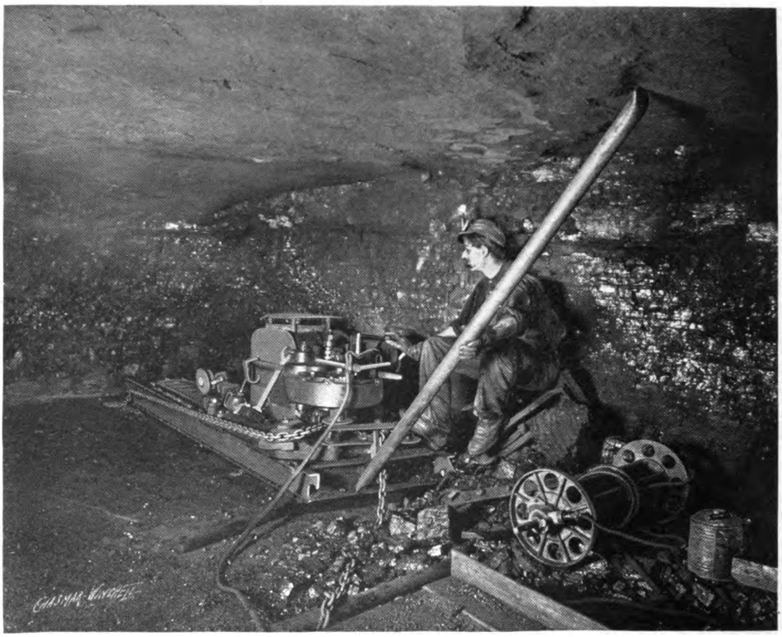
The problem of mining in these seams is complicated by bands of dirty coal, sulphur and black-jack, which occur just above the sandstone bottom. The roof is usually excellent, consisting of black slate, overlain by from two to three feet of limestone. But little propping is required.

LINN COAL COMPANY.

This was the first mine to penetrate the No. 5 seam. Their first operations were begun in 1902, in the No. 6 seam, and later they sunk to the No. 5, abandoning the No. 6 seam. The entries are driven 15 feet wide, and the rooms 45 feet wide. The accompanying sketch shows the arrangement at the foot of the shaft. The loaded car bumps the empty off the cage and straight out from the shaft about 60 feet, to the run-around, where it is picked up by a mule and gathered into a trip. Twenty-five pound steel rails are used on the main entry and 16-pound rails in the rooms and cross entries. The rooms are provided with two tracks for convenience in loading. The coal is mined in both rooms and entries, with the Sullivan electric chain room and pillar machine, which cuts to a depth of five feet and makes a kerf six inches in height. The accompanying series of photographs, taken in the Linn Coal Company's mine, illustrates the method of operation of this machine, which differs in important respects from that of chain breast coal cutters.

The peculiar feature of the Sullivan machine is that after making a rib cut, in the same manner as the ordinary breast type, the rear half of the frame is detached, the rear or take-up jack set against the right rib, and the anchor jack set in the left hand corner of the room. The machine is then started cutting sidewise from right to left across the face. It pulls itself along by the feed chain stretched between the two jacks, and in this coal, which is difficult cutting, proceeds at the rate of from 14 to 21 inches per minute. When the left rib is reached, the machine is backed out, coupled to the rear half of the pan, and then dragged back across the room to the right hand track and mounted upon the truck, all under its own power. A truck of the self-propelling type is employed, and all operations of the machine are performed under its own power, without hand barring or heavy lifts of any description. This machine makes a perfectly even cut on the bottom, so that no coal is left below the cut, to be raised by hand after the coal has been shot. Owing to the small space occupied by this machine in front of the coal (about six feet), the debris and dirty coal does not need to be kept so far back from the face as in the case of the ordinary breast machine. This fact materially reduces labor in cleaning up the face and loading the co

Swinging to the right rib for the first cut. The Sullivan machine performs this operation, as well as all others, under its own power.



Beginning the "sumping" or corner cut.

In this mine, one of these machines, operated by a man and boy, has undercut 2458 tons of coal in 15 days, one-half of this being in entries.

The cutting is very hard, owing to the presence of sulphur. In one part of the mine, low coal, only four feet in height, appears, accompanied by a large amount of sulphur, containing brass sulphur balls, mother coal and black-jack. When the sulphur balls were encountered, the rear end of the bar was swung ahead to cut out the coal in front of the sulphur; then the forward end of the bar was thrown ahead, cutting the coal behind the sulphur. The machine was then swung back at right angles to the face, and the front of the sulphur was broken off or the whole ball jerked out. Progress in this portion of the mine was at the rate of 14 inches per minute.

Mule haulage is employed at present, but will be later replaced by electric locomotives. Each mule pulls about 100 tons per working day of eight hours. The hoisting shaft, 200 feet deep, is 7x13 feet, and the air shaft, 6x7 feet. The mine cars hold one and one-half tons. The hoisting engines are 16x32 inches, with a cone shaped drum, and the cages are of the self dumping, drop bottom type. Pneumatic signal bells are employed at the bottom of the shaft, top landing and engine room.

The top works present some interesting features. The coal from the mine is dumped into a large weigh-hopper, from which it may be deposited on either of two shaker screens, by means of a balanced chute, which is operated by a lever from the weigh office. One screen serves the bins, from which wagons are loaded, and the coal is sized to large lump, five-inch lump, two to five-inch nut and egg, one and one-quarter-inch nut and slack, all in separate bins. On the railroad side the other screen serves three tracks, so that three sizes of coal may be loaded at one time. Two-inch nut is run into the five-inch nut by an independent chute from one to the other. Sheets are provided for covering the screen when mine run is to be loaded.

POWER PLANT.

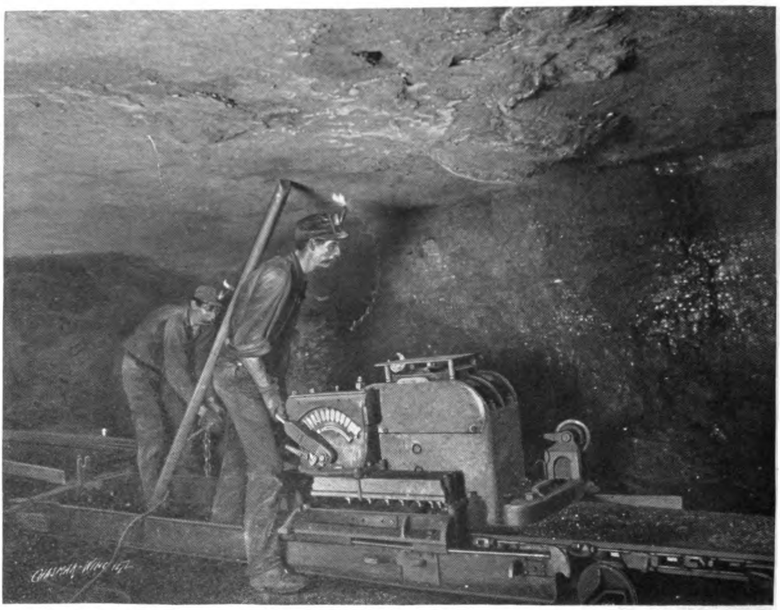
The boiler plant consists of one 300 H. P. battery which is fed with screenings, conveyed to the boiler room by an elevator from the tipple. This elevator is driven by the shop engine, which also operates the blower for fires in the shop, machine tools, etc. The company builds its own cars in this machine shop. The mining machines are operated by a direct connected General Electric generator of 100 K. W. driven by a 150 H. P. engine.

The officers of the company are Mr. J. A. Welton, president; Mr. A. L. Brocksmith, secretary and general manager; Mr. E. G. Hooper, mine manager.

CHICAGO & BIG MUDDY COAL & COKE COMPANY.

The Pine Knot mine of the Chicago & Big Muddy Coal & Coke Company is the only shipper which continues to operate the No. 6 seam. Conditions in this seam are very difficult for machine mining. Immediately above the hard sandstone bottom is a layer of eight inches of dirty coal, covered by a band of sulphur and rock, one and one-half to two inches in height. Machines of the breast type were first installed, but found difficulty in cutting, owing to the fact that the cutter bar ran either up into the sulphur or down to the sandstone, and in either case results were unsatisfactory. Sullivan machines were later installed and found no trouble in working in the eight-inch band referred to, since the cut made was perfectly horizontal. After working in this manner for some time, the coal became lower and the sulphur band and bottom were from three to five inches apart, instead of eight inches. This made very difficult cutting, and lately the coal has been cut above the sulphur band. On consecutive cuts the

Completing the "cumping" cut and detaching pan, or rear half of frame, before cutting across the face. The illustration on the front cover shows how this continuous cut is made.



Backing out at left rib and attaching to pan.

machines have averaged 20 feet per hour, in spite of the hard cutting. This mine has closed for the summer, and the machines have been taken out, owing to labor troubles.

The officers of this company are Mr. J. D. Whiteford, vice-president and general manager, Fisher Bldg., Chicago; Mr. Wm. McLearn, general superintendent, Marion, Illinois; Mr. C. Rees, mine manager at Bicknell.

KNOX COAL COMPANY.

The mine of the Knox Coal Company is located about three-quarters of a mile southwest of Bicknell on the I. & V. Railroad. They have operated the No. 6 seam for several years, but have recently abandoned it, and have continued their shaft to the No. 5. This work was completed in record time. The main shaft was sunk 100 feet in 25 days, and is 8x16 feet. The air shaft, 6x8 feet, contains two compartments, one for air, the other for a man-way. The coal here averages seven and one-half feet thick, and the roof and bottom are the same as those found in other parts of the district. At present, entries only are being driven, in preparation for autumn business.

All cutting is done by the Sullivan class "CE," 250 volt electric machines, making a six and one-half foot cut. The rooms will be driven 35 feet in width and the entries are 15 feet wide. An automatic switch-back bottom will be arranged at the foot of the shaft, and the coal will be handled from one side only. The machines at this mine are each cutting from six to seven entries in eight hours, producing about 200 tons of coal each. The coal contains considerable sulphur, which lies directly upon the bottom, but this does not hinder the operation of the mining machines.

A 150 K. W. generator, direct connected to a 240 H. P. straight line engine, is employed for operating the mining machines. The mine cars hold two tons, and self-dumping cages are employed. The screens are of the gravity type.

Result of a blast, after undermining the coal with the Sullivan Machine.

This mine will eventually have a capacity of 1500 tons per day, and electric haulage will be installed to take care of this output. Mr. S. W. Parish, Harrisburg, Ill., is president of the company. Mr. Wm. A. Cullop, Vincennes, Ind., is vice-president, and Mr. C. Linn, mine manager. Mr. J. Winters, to whom we are indebted for this description, is general manager.

FREEMAN COAL COMPANY.

The Freeman Coal Company has just begun operations in the No. 5 seam, and is opening up its mine at the present time for an eventual production of about 2000 tons per day. Machines were installed about a year ago, and the Sullivan type was adopted after experiments with machines of other makes. The breast type was found to leave considerable coal on the bottom, which had to be raised at additional expense. The Sullivan machine cuts directly upon the bottom. The coal is from seven and one-half to eight feet high, and is of the character already described. Two and one-half ton mine cars are employed, on a 40-inch track. Self-dumping cages are used and the tipple contains gravity screens, arranged to feed onto three separate tracks at once. The coal in this mine averages 50 per cent. lump when shot from the solid, and about 75 per cent. lump when mined by machines.

The officers of the company are Mr. Richard Freeman, president; Mr. Chas. Freeman, secretary and manager, and Mr. H. G. Conrad, mine manager.

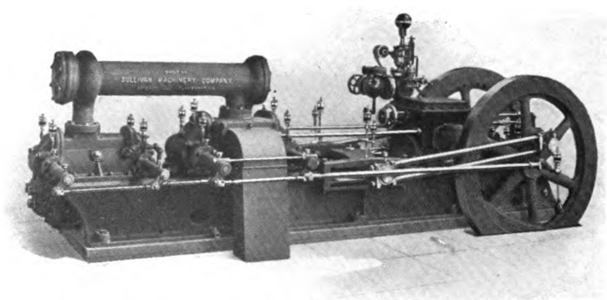
TECUMSEH COAL & MINING COMPANY.

This is the latest company to begin operations in the Bicknell field. Their shaft, 160 feet deep, is east of the town, somewhat in the bottom lands. The hoisting shaft is 9x17 feet in the clear, and the mine will be served by a hoisting engine with 18x36-inch cylinders, and a five-foot drum. The entries will be driven 12 feet wide, and the rooms will be 40 feet in width. The mine car holds two tons, and the track gauge is 40 inches. The coal will be loaded into the cages from two sides of the shaft.

A 20-machine Sullivan straight-line, two-stage compressor is now being installed. This compressor has a steam cylinder 24 inches in diameter by 30-inch stroke, and air cylinders 26 and 16½ inches in diameter by 30-inch stroke. Sullivan class 5 pick machines are to be used. These machines weigh 825 pounds and cut to a depth of 5½ feet.

The mine will eventually have an output of 2000 tons, and the equipment and methods employed will be modern and first class in all respects. Shipping will begin early in the fall.

The officers of the company are Mr. Jos. M. Martin, president; Mr. W. H. Howe, vice president; Mr. O. H. Martin, secretary and general manager, Chicago.



Sullivan Class W B-2 Compressor. Air inlet side.

MINERAL PROSPECTING AT COBALT.

General view of Cobalt, with Cobalt Lake in the foreground. The Coniagas and Trethewey Mines are visible in the distance.

DESCRIPTION OF THE DISTRICT.

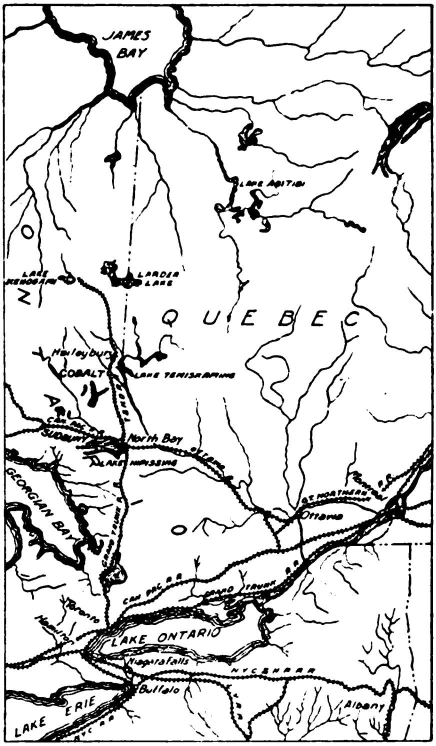
The Temagami district of Ontario, of which the town of Cobalt is the center, came into prominence less than 18 months ago, as the richest silver mining field in the North American Continent. Cobalt lies due north of Toronto, and is about 90 miles northeast of Sudbury, known for its deposits of nickel and copper ores. At Cobalt numerous metals are found, in addition to silver, including nickel, arsenic and cobalt. Some idea of the richness of the silver deposits may be gained when it is stated that a carload of 30 tons of ore from the new Ontario Mine was sold in 1906 for between $75,000 and $80,000. Nuggets of pure silver are occasionally found, ranging from a fraction of an ounce up to hundreds of pounds in weight.

The minerals occur, together with their matrix of calcite, in narrow veins ranging from one inch up to 16 or 18 inches in width. One or two veins are nearly two feet wide, but this is exceptional. The Trethewey vein, from which the carload mentioned above was taken, is about eight inches wide. These veins strike in all directions, as though the crevices which they fill had been caused by shrinkage strains set up during the cooling of the ore-bearing rocks. They pitch at angles inclined slightly from the vertical. These veins frequently crop out at the surface, being identified by the white calcite. Many important deposits, however, do not extend to the surface, and of these, the only indication, if any, may be a joint in the rock, or a thread of free silver filling an infinitesimal crevice.

The country rock is commonly known as diabase, but strictly speaking, consists of diabase, usually overlying a series of metamorphosed fragmental or conglomerate rocks of the Lower Huronian period, which in turn cover green stone and other tougher rocks, forming the Keewatin series. Occasionally the green stone appears at the surface, indicating an early upheaval and subsequent removal of the original surface strata by glacial action. The country is well wooded and hilly, with numerous small lakes.

PROSPECTING METHODS.

The first step in the development of a mine is to clear away the timber. The



Map showing location of Cobalt.
[From the Mining and Scientific Press.]

soil and surface deposit, from one to eight feet deep, are then removed, laying bare the face of the rock. Prospecting, as usually practiced, consists in digging narrow trenches in the rock and in then sinking small shafts upon such veins as may be discovered in this way. If the vein continues to show promise after having been followed a few feet in depth, permanent development is undertaken. Otherwise, the prospect is abandoned and a richer vein sought elsewhere by means of a fresh trench. One of the larger companies, the Nipissing Mine, has employed a stream of water under heavy pressure, with some success, to clear away the surface deposit.

Open cut mining has been adopted in some instances, the ore being removed by underhand stoping. When the outcrop has shown unusual value, shaft sinking, followed by drifting and cross cutting, is the more approved method, since the veins ordinarily increase in richness with depth.

Important discoveries have been made by this method of prospecting. It is unsatisfactory, however, for several reasons. First, it shows the prospector only what is apparent upon the surface, and gives no indication either of the character and persistence of the vein below the outcrop, or of the occurrence and value of other ore deposits which do not come to the surface. The entire district contains numerous faults, which may shift the vein a few inches or many yards from the position shown by the outcrop. In some localities the ore bearing rock may be hundreds of feet deep. In others, as mentioned above, glacial action may have planed off the upper portion of the veins, leaving only the lower extremities to mislead the surface prospector.

Second, thorough trenching and surface testing is very expensive. The number of veins is so large, and their character so variable, that an operator cannot feel sure of the best location for a permanent shaft, until practically his entire claim has been cleared of timber, criss-crossed with trenches, and pock-marked with experimental cuts and holes. The tough, broken formation makes shaft sinking costly (from \$25 to \$50 per foot), and it must be indeed a well financed company to afford this expense on a claim of say 40 acres.

DIAMOND DRILLING.

The larger companies number in their staff men who have had practical experience in other mining fields, and these men have recommended the use of diamond core drills, to thoroughly prospect their holdings. The most notable example is that of the well known Timmons or La Rosa Mine, whose hold-

Kerr Lake Crown Reserve Mining Co.'s "S" Sullivan Drill (property of Ontario Government) drilling an angle hole under Kerr Lake. Silver Leaf Mining Co. at left.

ings have been thoroughly prospected to a depth of between four and five hundred feet by means of core drilling. This company now has records of all the veins which it controls, and possesses an accurate basis for future developments. The diamond drill is practically responsible for the success of this mine, as the surface showings were comparatively barren. A few other concerns have used diamond drills to good purpose, but as yet only a few machines, including the one owned by the Canadian Government, are in use.

Drilling is much more economical than the shaft sinking method, since four or five hundred feet of holes may be put down for the cost of one 50-foot shaft, five by eight feet in size. Thus an entire claim may be prospected to a considerable depth for the cost of a single shaft. If the mineral found warrants the development of the property, the operator is in a position to know just what it will cost him to reach the veins, and to work them. He knows in what locality and in what direction he may sink his shaft to best advantage, bearing in mind the underground development of his mine. If the drill records do not warrant development of the claim, the time and cost of shaft sinking has been altogether avoided.

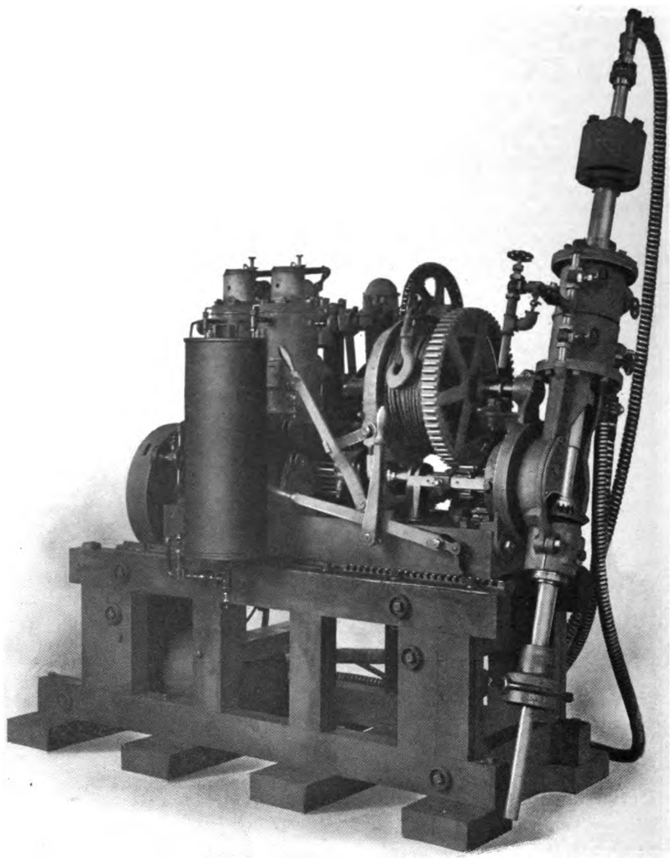
Aside from the toughness of the rock to be drilled, the formation is favorable to diamond drilling explorations, since it is compact, has but little surface deposit, and contains no bands of gravel, clay or other materials which will cave when water is introduced, thus no long lines of heavy casing are required to preserve the drill core. The diamond drill possesses the further advantage not possessed by other prospecting drills, that it is able to bore at any desired angle. As most of the veins are vertical or nearly so, it is necessary, in order to test them at depth, to sink the drill holes upon an angle of 60 or 70 degrees. The drills may also be used for underground work, in advance of drifts, crosscuts or tunnels, to prove the persistence of veins which have been located at the surface. Thus, if a vein which appears at the surface, disappears 50 feet below ground, the drill may be used either from the surface or from a station cut in the shaft or crosscut, to discover the lower portion of the vein, and its distance from the foot of the upper extremity.

The adaptability of these machines is as great as may be required by existing

mining conditions. As an example of this, it may be mentioned that diamond drill prospecting has been carried on from the surface of one of the smaller lakes in the Temagami district, and on a basis of its findings one of the most prosperous mines in the district has been established. The machines principally used hitherto have been of the Sullivan "Bravo" hand or horse power type, and the "S" and "Badger" drills operated by steam, or by belt from a gasoline engine. These machines have a maximum capacity of 500 feet.

A NEW TYPE OF DRILL.

A Sullivan class "H" machine has recently been shipped to the Boston-Cobalt Mining Company and this represents a type which combines desirable features for use in the Cobalt field. The drill has a capacity of 1000 feet, so that the deposits may be proved to any depth within the present prospects of the district. It is operated by an oil engine of the Mietz type. The accompanying photograph of the machine shows how the drill, engine, oil tank, and pump are all mounted on one frame. The drill is driven by a friction clutch, which is thrown in after the engine has attained the proper speed. This type of engine is desirable, owing to the high price of coal and hauling in the district. The most valuable feature of the machine, however, is the method employed for advancing the diamond bit into the rock. This is the standard single cylinder

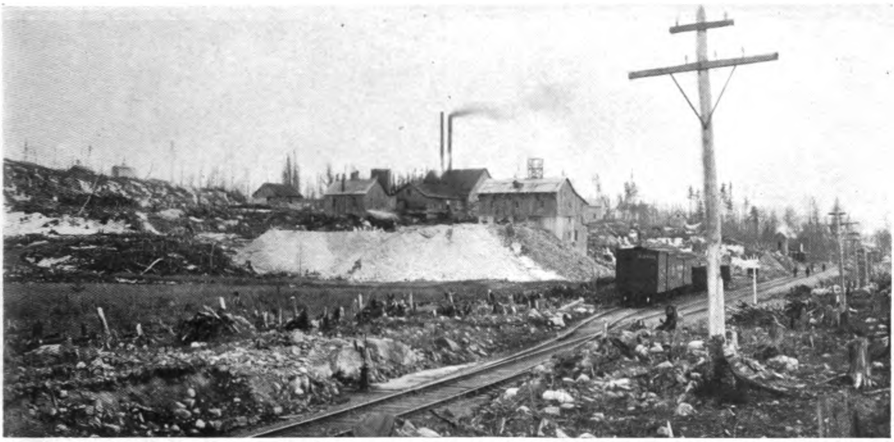


Sullivan "H" Diamond Core Drill, driven by oil engine, in use at property of the Boston-Cobalt Company.

hydraulic feed, employed on all larger Sullivan machines. By turning a valve, the operator can change his feed from fast to slow, can stop the progress of the bit altogether, or lift it off the bottom. Thus on the slightest indication of a change in formation from hard to soft, or from soft to hard, the operator may alter the feed of his machine to one which will secure the best progress, and at the same time cause the least wear upon the diamonds. This drill may be used either from the surface or underground, as desired, and will drill holes at any angle.

Although diamond drilling has been practiced but little thus far in the Temagami district, it is believed that the value of diamond drill prospecting in this region will be realized and advantage taken of this method to a much greater degree.

We wish to tender acknowledgment, for the information used in this article, to Mr. C. S. Lawrence, consulting mining engineer of Cobalt, and to Mr. H. F. Wells, Secretary and Treasurer of the Boston-Cobalt Mining Company, Boston, Mass., by whose courtesy the accompanying cut of the class "H" drill is reproduced.



The La Rosa or Timmons Mine. This property has been prospected with a Sullivan Diamond Drill to a depth of about 500 feet.

The Buffalo Mine, near Cobalt, showing the character of the country in this region.

MINE AND QVARRY

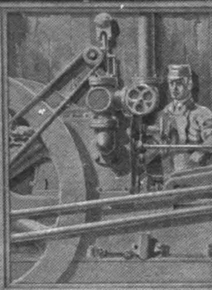
VOL. II. NO. 2. AUGUST, 1907

THE McCALL FERRY (PA.) DAM, ON THE SUSQUEHANNA RIVER.

Air Power in Dam Construction

Lead and Zinc Mining at Joplin

Soapstone



PVBLISHED BY THE SVLLIVAN MACHINERY CO. RAILWAY EXCHANGE BVILDING, CHICAGO.

TABLE OF CONTENTS.

Editorial 141

Air Power in the Construction of the McCall Ferry Dam . . L. R. Chadwick 142

Soapstone . . . . G. M. Bertram 149

The Lead and Zinc District of the Southwest . . . . Ralph S. Strong 155

The Hudson River Crossing of the New York Water Supply Aqueduct . . . . Jos. A. Brown, Jr. 161

A Straight Line Corliss Air Compressor . . . . H. A. Wainwright 163

Coal Mining in the Indian Territory . . . . . Geo. W. Blackington 166

MINE AND QUARRY

Vol. II. No. 2. AUGUST, 1907

A Quarterly Bulletin of News for Superintendents, Managers, Engineers and Contractors.

Published by the Advertising Department of the Sullivan Machinery Company.

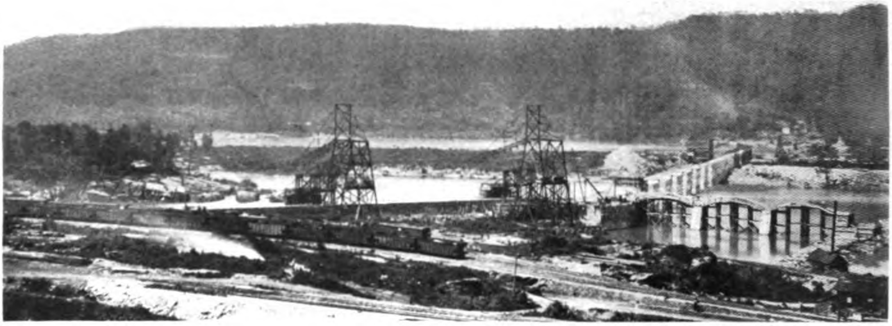
Address all Communications to MINE AND QUARRY, Railway Exchange, Chicago. Sent to any address upon request.

Readers are requested to notify MINE AND QUARRY of any correction or change in address.

The advantages and economy of a central compressed-air power plant for operating scattered machines of various kinds on contract work are well illustrated in the construction of the Susquehanna River dam, at McCall Ferry, Pa., elsewhere described. The efficiency which compressed air imparts to engines, even at long distances from the compressor, renders it superior to steam, while the cost of furnishing air from a central installation of high fuel economy is much less than that of maintaining isolated steam boiler plants for each machine.

The development of "sheet ground" at Joplin marks an epoch in the life of the district. Hitherto the companies have been content to strip the "soft ground" of its rich pockets of high-grade ore. The question has been: "When these are exhausted, will the district cease to be a factor in the production of lead and zinc, or are there other deposits of paying ore at depths not yet reached?" The drill prospecting and the mines opened on the "sheet ground" during the last few months have answered this query satisfactorily, and indicate that the district is yet in its infancy. The American Mining Congress will meet at Joplin early in November. For this reason, and because of the unprecedented activity in the district during the last eight months, the résumé of mining conditions on another page may be of interest at this time.

The Isthmian Canal Commission has recently purchased twenty-four Sullivan stone channeling machines of the largest size, driven by compressed air, with which the lock walls and portions of the canal are to be channeled. It is evident from this that the lessons of the Chicago Drainage Canal, of the Niagara Falls wheel pits, and of other watercourses through rock, more recently constructed, are not to be disregarded at Panama. These earlier enterprises have demonstrated that a channeled rock wall will stand indefinitely without deterioration from the elements, and that the item of friction is greatly diminished, as compared with the rough-hewn wall resulting from drilling and blasting. Noteworthy construction economies also attend the use of channelers. These machines cut exactly to the line as surveyed, so that subsequent filling or trimming is unnecessary. The wall itself and the rock behind it are not shattered by explosives, thus obviating both the building of retaining walls and the danger of rock falls or slips.



General view of the McCall Ferry Dam and its location.

AIR POWER IN THE CONSTRUCTION OF THE McCALL FERRY DAM.

WRITTEN FOR "MINE AND QUARRY"

By L. R. Chadwick, M. E.*

The use of compressed air in large engineering undertakings is no longer confined to the operation of drills and channelers for rock excavation. By means of a central plant, power may be supplied to contractors' machinery of every description, at a cost far below that of steam, and with much greater convenience.

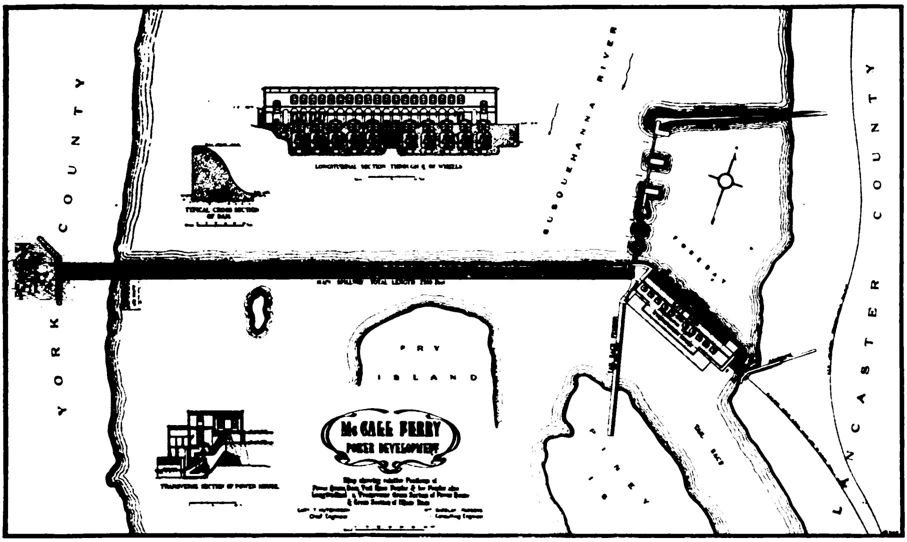
THE MCCALL FERRY POWER CO.

A notable example of the advantages of compressed air for such purposes is that afforded in the construction of the water-power dam across the Susquehanna River at McCall Ferry, Pa., by the McCall Ferry Power Co., of New York. The power developed by this installation will be converted into electrical energy, to the delivered capacity of 100,000 horsepower, and distributed, for lighting and manufacturing purposes, to neighboring cities. The enterprise, which involves the expenditure of $2,500,000, ranks first among the numerous developments of water power now under way in this country, and in point of magnitude and engineering difficulties is equalled by few single or isolated undertakings in progress.

The river is 2,500 feet wide at this point, and the dam will have a total length of 3,000 feet, including the sections which extend upon the land. It is 65 feet wide at the base, 10 feet wide at the crest, and 55 feet high; and it will raise the water level to a point 15 feet higher than at present, impounding a lake six miles long, a mile wide, and 30 feet in average depth.

The work began in October, 1905, and is now more than half completed. The general plan consists in laying bare first one-half of the river, by means of a coffer-dam, and then the other, building the dam in two sections. The presence of Fry Island in mid-stream made this plan feasible. The diagram on page 143 shows the relative location of the dam, power-house, and of Fry Island, while the photograph above gives an idea of the river and its banks at this point.

* 42 Broadway, New York.



General Plan of the McCall Ferry Power Development.

THE AIR-POWER PLANT.

The first work undertaken, after the site on the east bank was cleared, was the construction of a power-house and the installation of two air-compressor units, to furnish power for the machines and tools to be used in construction. The view on page 144 shows the plant in construction, and that on page 146 the completed engine-room.

The compressors, which are duplicates in all particulars, were built for this work by the Sullivan Machinery Co. at their Chicago shops. They are of the class "WX" Corliss cross compound steam and two stage air type, with steam cylinders 16 and 32 inches and air cylinders 30 and 18 inches in diameter, with a common stroke of 42 inches, and a capacity of 2,600 cubic feet of free air per minute each, at 75 R. P. M.

These machines are of unusually substantial construction, to withstand the severe duty required of them. They are run condensing, and a steam receiver and reheater is located beneath the engine-room floor, between the steam cylinders, to prevent heat losses in transmission from one to the other. Air efficiency is provided by an adequate system of water jackets and by a large receiver intercooler, through which the air passes in its course from the low-pressure to the high-pressure cylinder. The air inlet valves are of the semi-rotary pattern, positively driven by eccentrics on the engine shaft, and these, as well as the automatic poppet discharge valves, are so placed and designed as to reduce the elements of clearance and leakage to their lowest terms.

These units discharge into separate receivers outside the engine-room. Air is led from these receivers, at 100 pounds pressure, in a ten-inch main, which is reduced to eight, then to six, and finally to five inches in diameter, as the side lines branch off. Machines are operated by the air at a distance of nearly three-quarters of a mile from the compressors.

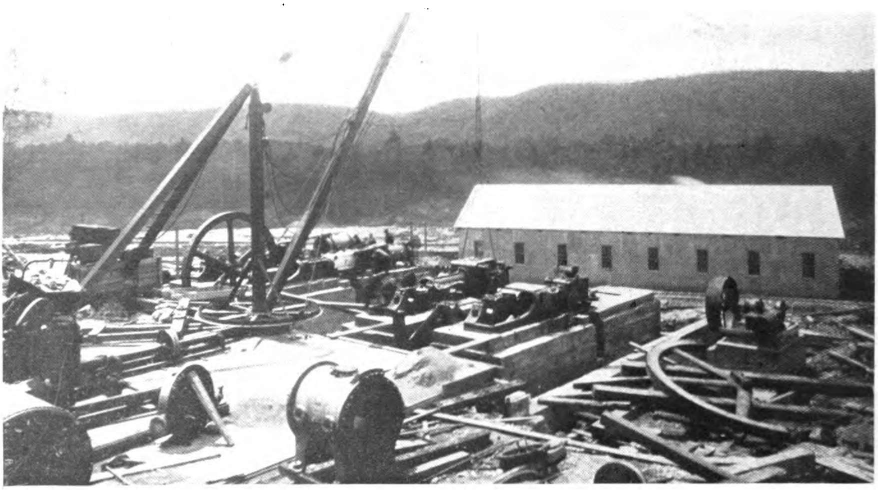
CONSTRUCTION METHODS.

With the completion of the power plant, work was begun on the crib cofferdam in the eastern channel. When this was finished and the channel

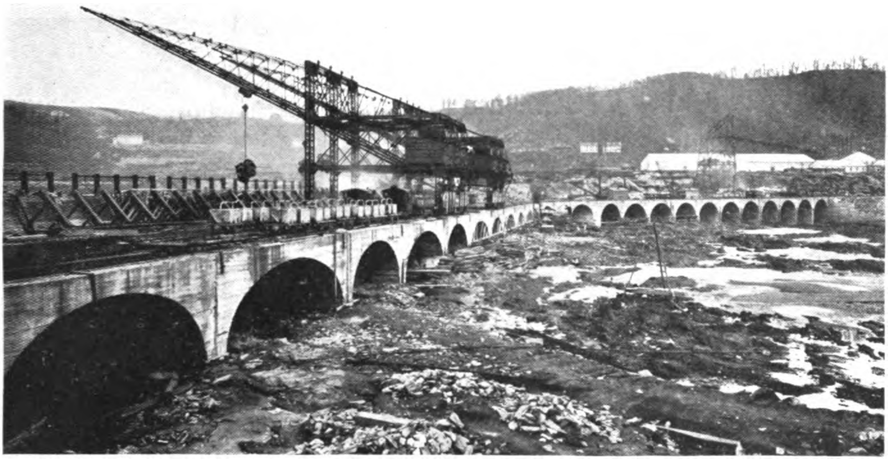
emptied, a construction bridge of solid concrete masonry was erected, from which to build the dam. This plan was adopted on account of the heavy floods which frequently occur on the Susquehanna, necessitating a system which would permit the placing of concrete in the dam even when the foundation was under water. The construction of this bridge, shown on page 145, was an engineering feat in itself, particularly in the speed with which it was built. It connects the eastern shore with Fry Island, is 1,100 feet long, and wide enough for four railroad tracks. The arches are 40 feet wide and from 20 to 50 feet high, and the entire bridge was completed in 45 working days.

Meanwhile, a concrete mixing plant had been set up, having a total capacity of 3,000 cubic yards per day. A quarry was opened at Conowingo, 14 miles down the river, to supply stone for the concrete. The river bed was thoroughly cleaned and tested, in preparation for the foundation. The construction of the foundation and of the dam is carried on by means of pelican cranes, five in number. The concrete is delivered to the cranes in one-yard steel dump buckets, loaded on trains of flat cars. These trains consist of five or six cars, with two buckets on a car, and are drawn by "dinky" locomotives. As the train arrives between the vertical members of a crane, the bucket is lifted from the car, transported laterally to the desired place, and there lowered and dumped.

The processes of mixing the various grades of concrete, handling the loaded cars and returning the empties, are performed with wonderful speed and accuracy, possible only by means of the thoroughness of organization, even to the smallest details, which is characteristic of this undertaking.



The Air-Compressor Plant in course of erection.



The Construction Bridge.

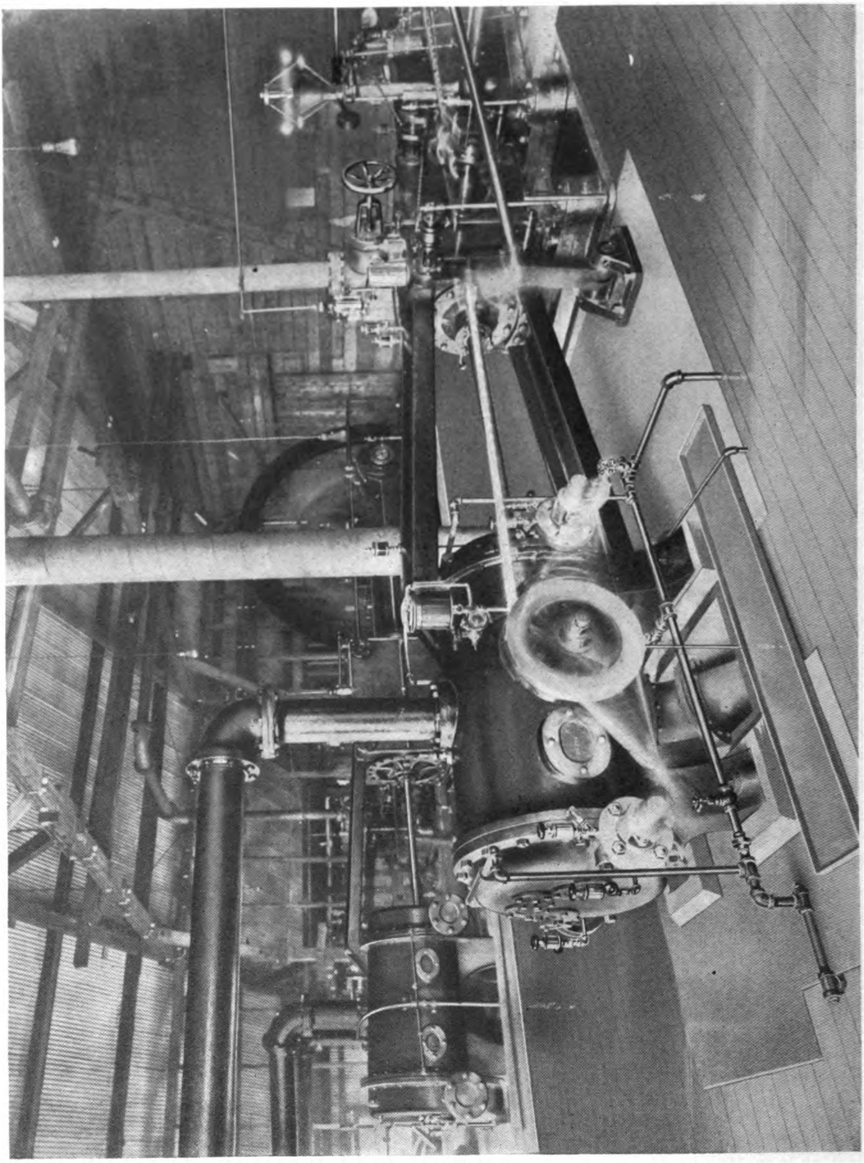
THE DAM STRUCTURE.

The photographs on pages 142 and 149 show the typical structure of the dam. The section on the island is built of solid concrete, but that which crosses the eastern channel consists of piers 40 feet wide and 50 feet apart. The foundation is solid and is built to a height of four or five feet above the present level of the river. The cofferdam, which laid bare this channel, has now been removed, allowing the river to resume its course, passing through the intervals between the piers. The cofferdam in the west channel is finished, diverting the entire flow to the east channel. The western section of the dam will be built solidly from the shore to the island from a construction bridge like that employed in the eastern channel. When completed, the cofferdam will be torn out, and the intervals between the piers in the east channel closed, one by one, with steel stop-logs and concrete, completing the main spillway.

The dam is rounded off at the top on its up-stream face. The down-stream face is curved to a parabolic convex surface, fuller than that assumed by a mass of water running over the crest to the maximum depth. The effect is to cause the water to hug the surface closely and thus make impossible the formation of a vacuum between the dam and the overflowing water. About halfway from crest to toe the curve reverses, so as to shoot the water away from the dam in a horizontal direction. This will prevent scouring of the foundations.

This curved spillway has involved a structure founded securely upon bedrock, which, as to both shear and tension, is many times as strong as the most liberal factor of safety requires. To provide for expansion and contraction, and so avoid the internal strains so dangerous to such a structure, the dam is built in sections of 40 feet, between which layers of compressible material are introduced in a vertical plane. Even with extreme variations of temperature the dam will not be subjected to harmful stresses.

The consideration of avoiding interruption in service by ice during flood times has led to the adoption of ice guards on a liberal scale and complete in character. The ice will naturally take



The Air-Power Plant, consisting of two Sullivan Corliss Air Compressors.

the west channel, away from the power-house. The latter is thoroughly protected, however, by a rock fill, forming the upper wall of a forebay, and by the angle at which the house itself is set, which will throw all ice entering the forebay into a special chute next the eastern shore. These features appear plainly in the photograph, page 142.

POWER-HOUSE.

The power-house is shown in elevation in the diagram on page 143. It extends out from the eastern or Lancaster County shore a distance of 300 feet, joining the main spillway and forming itself a part of the dam. It is set at an angle of 45 degrees with the shore, and is 500 by 100 feet in size. Page 149 shows some of the features of construction. Each of the ten vertical water wheels or turbines will be capable of developing 13,500 horsepower when operated under a 53-foot head, the water passing through the draft tubes at a rate of 16,000 gallons per second. Each turbine will be coupled to a 7,500-kilowatt generator. Two additional exciter units will be installed later.

After leaving the wheels, the water will pass into the river bed below the dam through a tail race 150 feet wide by 11 feet deep. The construction of this tail race involved the removal of about 125,000 cubic yards of rock.

USES OF COMPRESSED AIR.

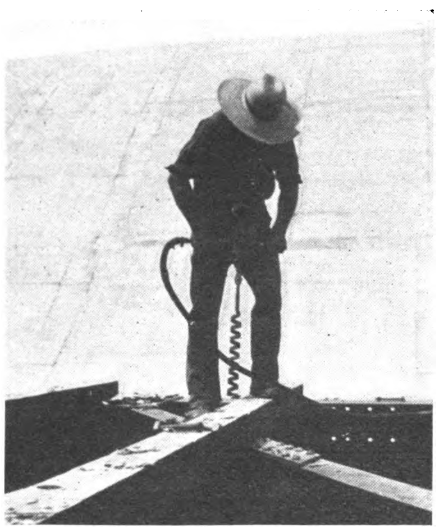
As stated earlier in the article, air power from the central compressor plant has been used in all feasible ways, from the very beginning of this undertaking. In the excavations which were necessary to give the dam a solid rock foundation in the river bed, and in the blasting work in the tail race, standard Sullivan air-driven rock drills were used. In the erection of the cofferdam cribs, which are built of immense timbers spiked together, the holes for the spikes are bored with air-driven augers. The concrete mixer, consisting of eight units, each with its own engine, is run entirely by air power.

For depositing the concrete in place along the dam there are five huge traveling pelicans, two of which have two engines each, and three, four each. Besides these, there are at work at various points along the dam five derricks of five tons capacity each. There is also a thirteen-hundred-foot cableway, capable of handling a five-ton load. The engines on all this machinery are operated by compressed air.

In the machine shop, where the repair work is done and the spikes and bolts used in construction are made, as well as in the carpenter shop, where the cement forms are built, the power is derived from an engine driven by compressed air. An eight-hundred-pound steam hammer in the machine shop is also worked very successfully by air power.

ECONOMY OF THE PLAN.

The advantages of this method over that of running so many scattered



An Air Auger.

Construction Bridge, Forebay, and Part of the Dam.

machines by steam are easily seen. The cost of producing the requisite amount of air with compressors of the Corliss cross compound condensing type, developing a horsepower on from 14 to 16 pounds of feed water per hour, and the resulting low fuel consumption, is much less than the cost of steam to do the same work. The loss in transmission of air power is very slight as compared with the loss due to condensation in steam pipes. An expensive system of distribution of water and coal is avoided. Individual boilers for the hoisting engines, as well as firemen to tend them, are dispensed with. Repairs on such boilers, which would be great, owing to the inferior class of labor necessarily employed, are saved. The increased comfort to the men arising from the absence of heated parts about the machines, greatly facilitates the progress of the work.

At the quarry, some fourteen miles away, where the crushed stone for use in construction is prepared, an 1,160-foot Sullivan class WB-2, straight line, simple steam, two stage air compressor drives a number of rock drills.

Such have been the demands of the work that since the compressors at the dam were installed in May, 1906, they have frequently had to run during the entire 24 hours for several days at a time, yet at no period has the work been held up for want of air pressure, and the cost of repairs has been practically nothing. The compressor at the quarry has several times been heavily overloaded, yet it has always been able to meet the requirements on it without the slightest indication of a break-down. All three of the compressors, as well as the Sullivan drills, in use about the dam and at the quarry, have done their work in a thoroughly satisfactory manner, and receive the heartiest commendation of the engineers in charge.

Acknowledgment is tendered the Power Company's engineers for photographs and information used in preparing this article.

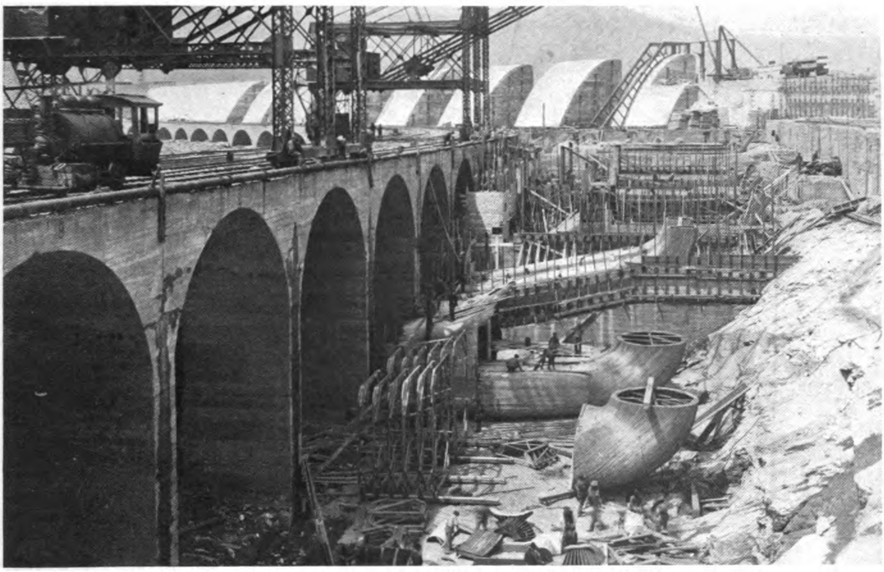
SOAPSTONE.

By G. M. Bertram, M. E.*

A great deal is known about building stone for exterior and interior purposes, such as marble, granite, sandstone, and slate, from the simple fact that immense beds of these formations are found in various sections of the country. Soapstone, however, cannot be classed with these other stones, owing to the narrowness of the veins or deposits in which it is found, and the limitation of the working quarries to a single section of the country.

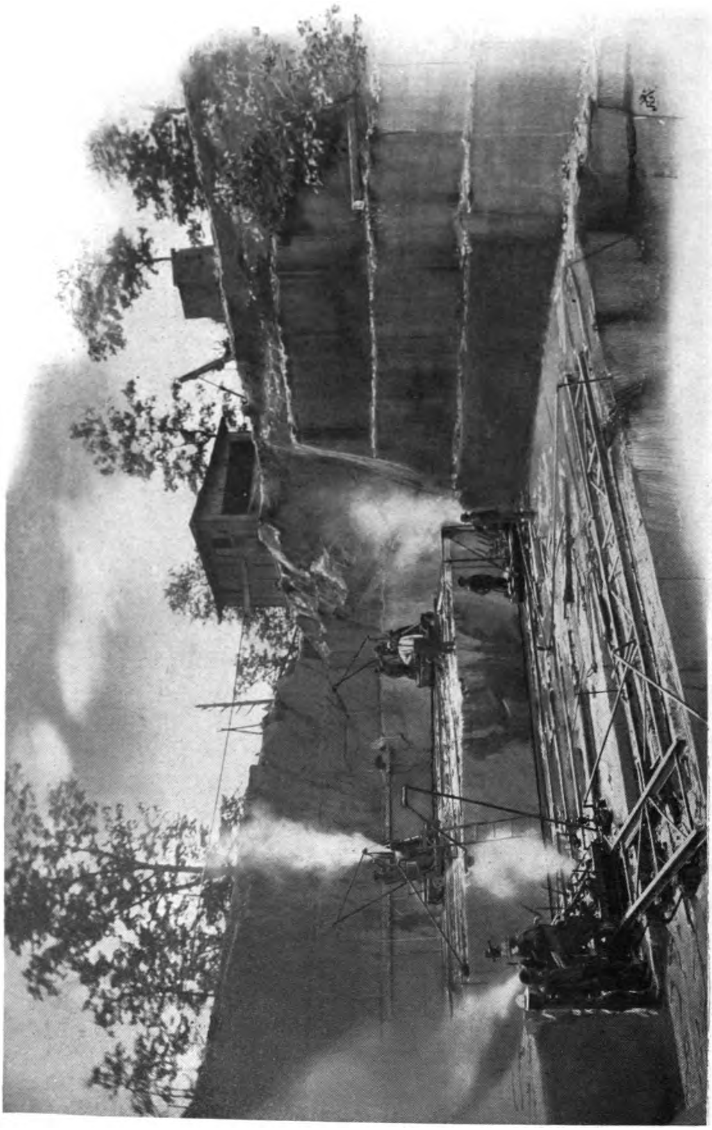
LOCATION OF THE DEPOSITS.

Take a map of eastern North America, and draw a line parallel to the mountain ranges, about twenty miles east of the Blue Ridge. This line will pass through, or very close to, the working talc and soapstone veins of this country. In North Carolina the formation first appears in the form of talc, which gradually hardens as it enters Virginia, until the first active soapstone quarry is reached in Campbell County. Following the line to Nelson and Albemarle Counties, the chief soapstone-producing section of this country is reached. At the present time ten quarries are being worked here, some of them just opening and others that have been producing soapstone for from fifteen to twenty-three years. Farther north, in Orange County another quarry is opened, and again in Fairfax County. This latter, however, is only producing soapstone dust. In Carroll County, Maryland, another quarry is producing regular soapstone products and dust. The vein is found in the form of talc and serpentine in Cecil County, Maryland, and, tracing the line north, another serpentine outcrop is found near Easton, Pa. Other outcrops are near Lincoln, New Jersey; Winsted,



Building the Draft Tubes for the McCall Ferry Power-House.

*1300 Harvard St., Washington, D. C.



A Virginia Soapstone Quarry. The Sullivan Channelers on the upper floor are cutting vertically, while that on the lower floor, at the right, is undercutting.

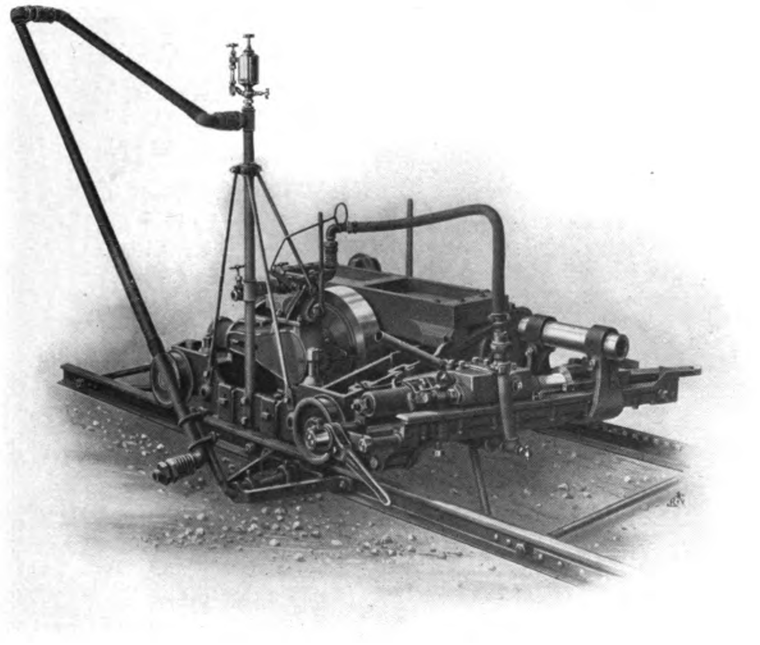
Conn.; Francestown, N. H.; in Windsor County, Vermont; and, finally, near St. Johns, Newfoundland, in the form of talc. The New Hampshire deposit seems to be an offshoot of the main vein, which turns more directly north to follow the general trend of the mountain ranges.

HISTORY OF THE INDUSTRY.

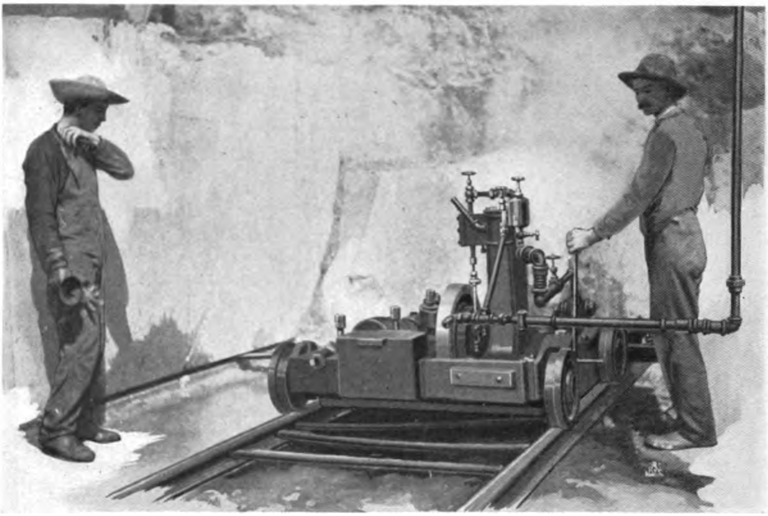
Soapstone was first quarried in New Hampshire about a hundred years ago, and as early as 1812 was shipped to Boston in the form of slabs, where it was used in the construction of soapstone stoves, some of which may still be found in old New England homes. The soapstone quarries of Albemarle County, Virginia, were started about 1883, the initiative being taken by Mr. James H. Serene, who at that time was manufacturing articles from soapstone. He contracted with a party for a certain amount of soapstone, which was taken from a plantation about five miles from North Garden, Virginia, on the Southern Railroad. On his visit to this plantation he found crude methods of working, but was struck with the quality of the stone and the quantity in sight. He interested New York capital in the venture, and, acquiring the property, they began to manufacture at this location. Even at this time methods were somewhat crude, and the business was run at a low margin for quite a number of years. Eventually, however, a spur from the C. & O. R. R. was run to this section. This materially helped in the solution of the problem, and added much to the prosperity of the company, which today is shipping about 700 carloads of slabs and manufactured soapstone articles per year.

QUARRYING METHODS.

Soapstone lies in horizontal deposits of considerable thickness, without stratification, so that it must be quarried on the bottom as well as on the four sides. Channelers are employed altogether for



Sullivan Class " VX" combined Channeler and Undercutter.



A Sullivan Undercutting Channeler at work.

this work, thus freeing the blocks without the damage and waste caused by blasting. The channelers in most general use are of two kinds—undercutters, and swivel-head machines for the vertical cutting. A combination of these two types has recently met with success for opening up new quarries. This is the Sullivan "VX" combined channeler and undercutter, shown on page 151. When undercutting, the channel may be put in within six inches of the top of the rail, and the standard supporting the chopping engine may be set at either end of the frame, to permit cutting out corners. The light weight and blow of this machine is also admirably suited to the uneven floor and soft rock near the surface. The undercut is usually four feet deep.

In a fully opened quarry, however, the "VX" is used for undercutting only, the vertical channels, usually six feet deep, being run by Sullivan size "6½" improved machines, which are preferred by nearly all the soapstone quarrymen in Virginia and Maryland. The channelers are operated by steam from a central power plant. 250 square feet per day is an average performance for the size "6½" channeler, while runs as high as 350 feet have been made. For the "VX" machine 150 to 250 square feet of channel is a day's work, depending on the length of the runs and the hardness of the veins.

The blocks, after being channeled and lifted out of the quarry, are taken to the gang saw, where they are sawed into slabs one and one-half inches thick. They are then cut into the desired sizes, planed, grooved, and finished on the rubbing bed. The necessary pieces are now fitted together, cemented, and securely held by wood screws, the presence of which may never be suspected in a finished laundry tub.

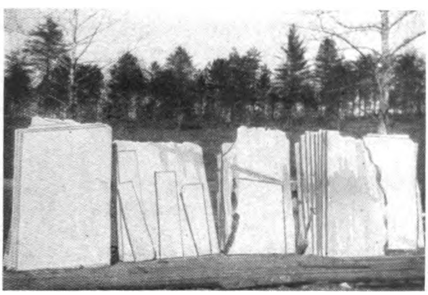
USES OF SOAPSTONE.

Laundry tubs and sinks are the chief forms in which soapstone is put on the market, but with the increase in production of late years has come a corresponding increase in the uses of soapstone. Among the more important of these are slabs for use in electrical work, such as switchboards, barriers, cell-bases, etc.,

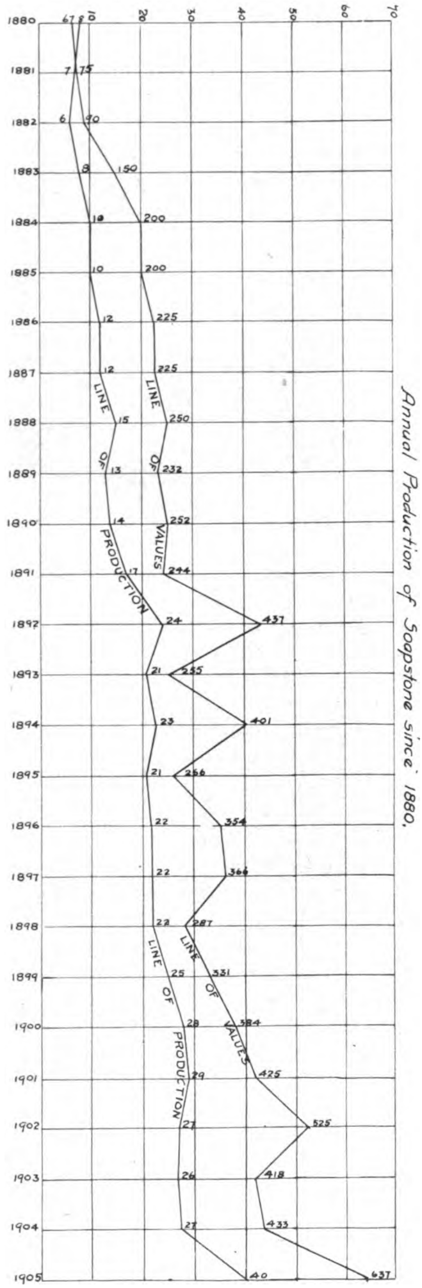
also for shower-baths, laboratory tables, acid tanks, fire-brick, griddles, foot-warmers, and many other smaller articles. The dust at present commands only a small market, but quite a varied one, since it is used by manufacturers of paper, paint, asbestos covering, rubber goods, graphite, foundry facing, fertilizer, etc. The accompanying sketch illustrates the progress of the soapstone industry through 1905.

The physical properties of soapstone warrant the wider uses to which it is being put. When of good grade it is unquestionably the best natural material for use in high voltage electrical insulation, sanitary installations of all kinds, laboratory purposes, acid tanks, and other uses to which a stone may be applied which is easily worked and at the same time tough and firm. It has high tensile strength, and an absorbent quality of from one-tenth to four-tenths of one per cent. It has high fire-resisting qualities, and great dielectrical strength, a piece one-half inch thick requiring thirty to forty thousand volts to puncture it. Pure commercial sulphuric, nitric, or muriatic acid has no effect on it, but hydrofluoric acid has a decided action. A mineral analysis of soapstone shows that its constituents are silica, aluminum, magnesia, and traces of iron oxide and lime.

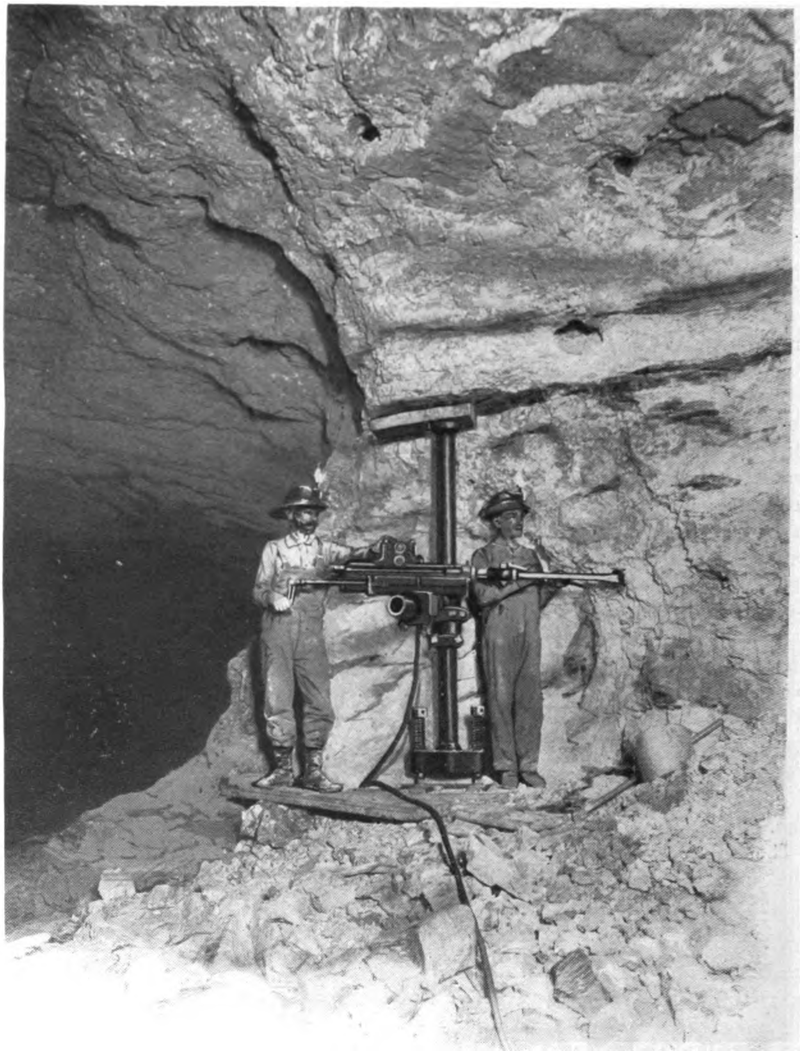
The writer is indebted to Mr. H. B. Guise and Mr. C. A. Williams for information contained in this article.



Soapstone Slabs from the gang saw.



Values are given in thousands of dollars.
Quantities are in thousands and short tons of 2,000 lbs.



Mining "Sheet Ground" in Southwestern Missouri; a Sullivan Drill at work.

LEAD AND ZINC MINING IN THE JOPLIN FIELD.

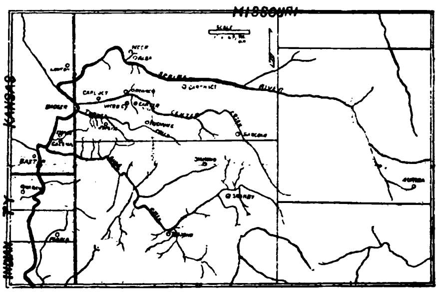
WRITTEN FOR "MINE AND QUARRY"

By R. S. Strong.*

Fifty-nine per cent. of all the zinc produced in North America, as well as a large quantity of lead, comes from Joplin, in southwestern Missouri, and its vicinity. The district of which Joplin is the center includes the counties of Jasper, Newton, Berry, and Green in Missouri, a few miles in Cherokee County, Kansas, and part of the Quawpaw reservation in Indian Territory. It extends 60 miles from east to west and 30 from north to south. (See the accompanying map.)

Joplin is a substantial city of 50,000 people, attractively laid out and well built in stone, brick, and steel. It possesses all the living facilities and advantages of any purely commercial center of equal population. Four trunk lines and several interurban roads connect Joplin with outside points and with the adjacent towns and camps. Five of these towns aggregate 120,000 inhabitants. The chief of these is Webb City, a few miles to the northeast, which is pushing Joplin hard for the title of the mining center of the district.

The mining industry began about 1860 and has continued until the present with hardly a break. Its growth during the past 13 years is illustrated by the attached diagram. (Page 157). $15,000,000 was paid for the ore produced in 1906, and $20,000,000 is the mark set by mining prophets for 1907. Zinc is now worth nearly twice as much as it was five years ago, yet the consumption of the country is greater than its production. In 1906 the Joplin district produced 278,000 tons of zinc ore and 39,000 tons of lead ore.



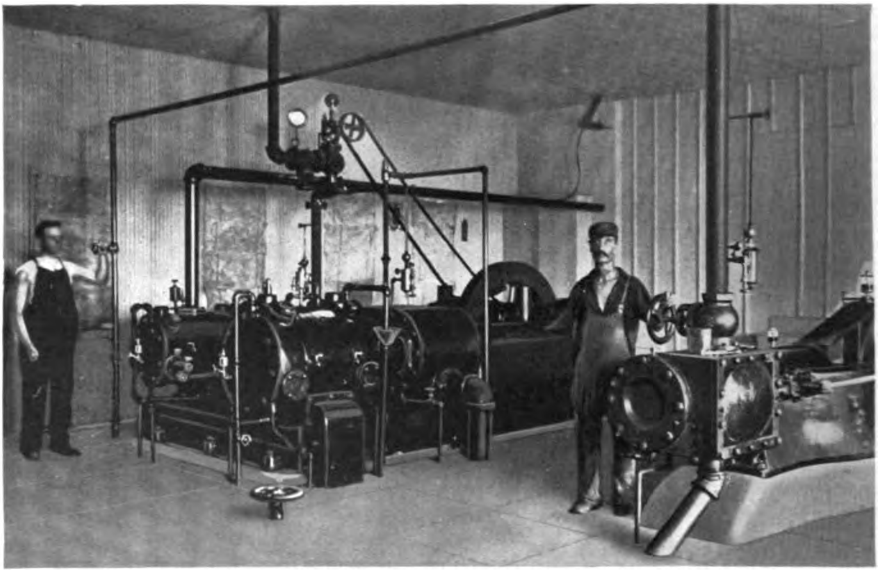
Missouri-Kansas Lead and Zinc district. (Courtesy of "Mining Reporter," Denver.)

*265 Oak St., Chicago.

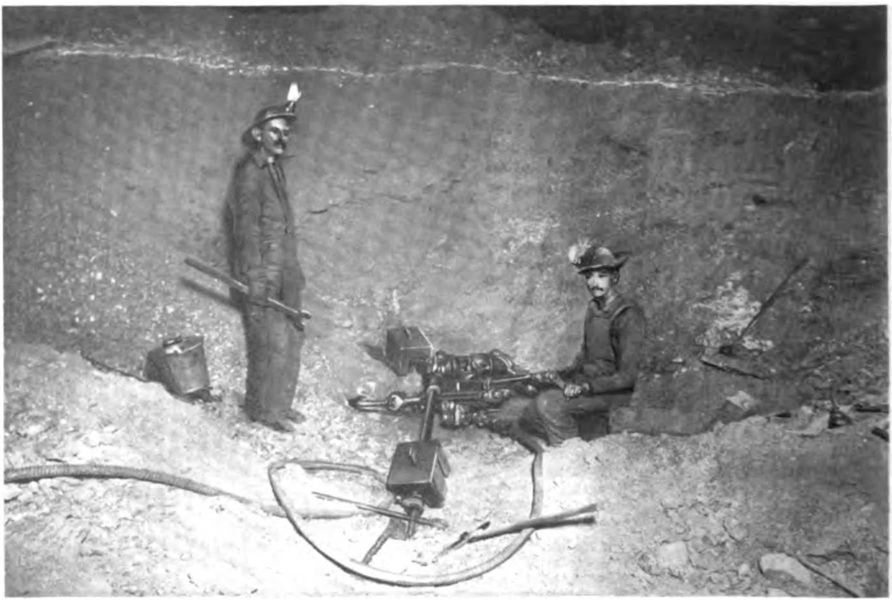
It is estimated that there are 800 producing mines in the district. Many of these are small operations, low capitalization being encouraged by the ease with which the ore is won from the "loose ground" or pocket formation, and by the fact that cash is paid weekly by the ore buyers from the smelters for concentrate at the mine.

The development of the "sheet ground" described below, however, demands a greater investment for equipment, so that in the future larger companies are likely to be the rule. In conducting mining operations throughout the district, the general plan has been to divide the properties into lots of from ten to 40 acres. These are leased to a company or an individual who in turn divides his holdings into sections and subleases them. Usual practice allows the owner and first lessee each ten per cent. royalty; this leaves the operator 80 per cent. of the ore value for himself, out of which he must pay for labor and material.

The usual value of well located and prospected mineral land ranges from $300 to $1,000 an acre. The miners are nearly all Americans, and many of them are substantial citizens. The working day is eight hours.



A Sullivan "Class W F" Duplex Air Compressor at Baxter Springs, Kansas.



Sullivan Drill on tripod, putting in lift holes at foot of a bench of ore. The upper portion of the ore face is visible in the background.

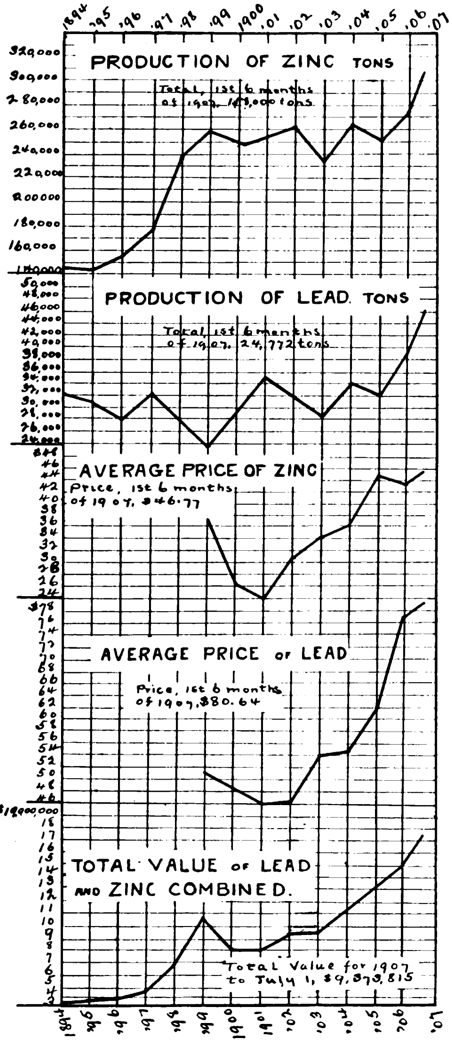
GEOLOGY AND ORE FORMATION.

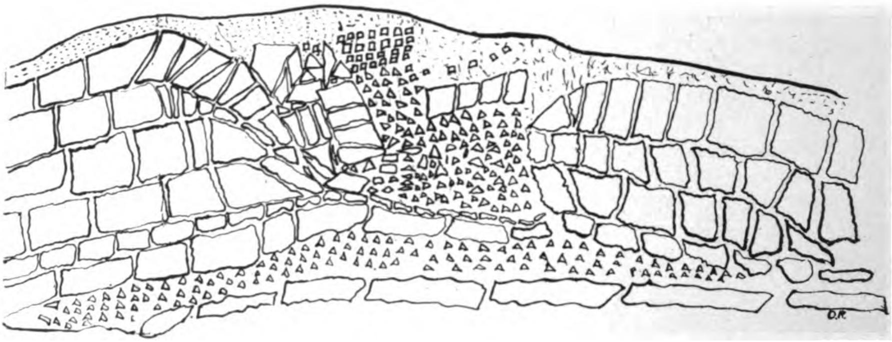
The topography of this mineral belt is similar to that of many agricultural regions in the middle and western states, consisting in rolling country, on which staple grains and fruits are raised. The ore occurs in the Ozark uplift, which is composed of slightly disturbed limestone strata of the sub-carboniferous period. This limestone contains numerous beds of chert or flint, in which lead and zinc are intimately associated. The ore formation is of two kinds: First the loose or "soft" ground, interspersed with clay or shale, and in which the ore bodies occur in pockets in the brecciated, shattered limestone; second, "hard" or sheet ground, ranging from a few feet to 30 feet thick, and found in large areas at depths of from 160 to 225 feet. (See diagram, page 158.) In this formation lead and zinc occur in sheets in the seams and cracks of the limestone. Good sheet ground yields from three to five per cent. of ore, which contains from 50 to 62 per cent. of metallic zinc. The output from "soft" ground is higher in percentage of ore, but less reliable, as there is no regularity in the size or location of the pockets.

The ore most abundant in this field is zinc blende, sulphide of zinc (Zns.). This occurs in several varieties, as pyrite or jack, marcasite or resin jack, and chalcopyrite or blue jack. Galena, or lead ore (Pbs.), occurs in the common form of bluish-black cubes, ranging in size from that of a pin head to blocks seven or eight inches across. Tiff or calcium carbonate is present in large quantities, and small amounts of barium sulphide, calcium fluoride, and double sulphite of iron or mundic are found.

PROSPECTING.

The deposition of the ore throughout the region is so irregular that actual penetration of all the ground to be developed is the only reliable basis for development. Prospecting is done by churn drills, and holes are sunk from 100 to 200 feet apart over the area being investigated. This method is somewhat unsatisfactory, as the cuttings cannot be relied on closely for assaying purposes. Diamond drilling has never been adopted in this field, but it is considered practicable for sheet ground, and investigations on this matter are being made by diamond-drill manufacturers. Churn drilling is usually done by contract at an average price of 90 cents per foot.





Sections of Typical Ore-Body in Webb City District, Showing Rich Pockety Upper Run with Sheet Ground Below.— ▲ Denotes Zinc Blende and ■ Galena.
(By Courtesy of "Mining Reporter," Denver.)

MINING PRACTICE.

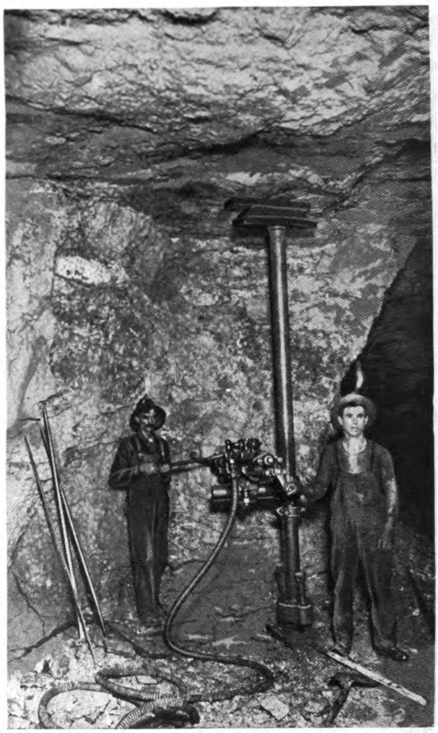
In soft ground the ore lies close to the surface and is mined by simple methods. Hand drilling usually serves to break the ground and the workings are heavily timbered to prevent caves.

SHEET GROUND MINING.

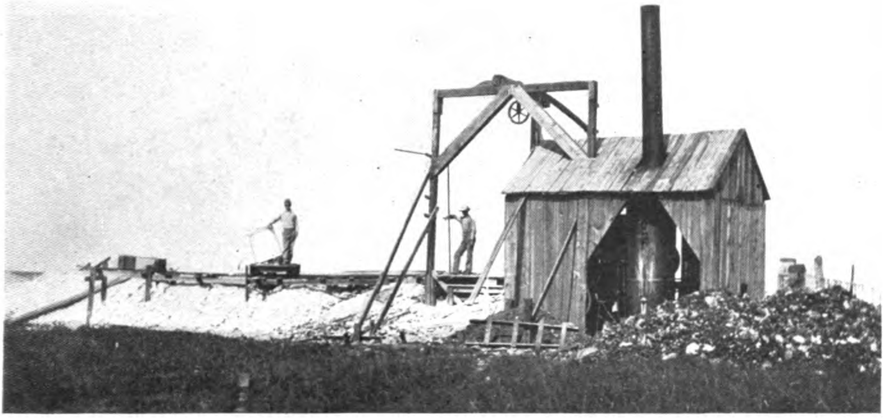
The development of the sheet ground is still in its early stages, but has already revolutionized mining methods and has established a new era in the district, prolonging its life indefinitely. The low grade of the ore, compared with that of the soft ground, implies that it must be mined and treated in large quantities and economically in order to show a profit. Heavier machinery and improved processes are therefore being installed, their introduction being further justified by the greater reliability and continuance of these ore deposits.

The usual method of developing sheet ground is by 5x7-foot vertical shafts, which are cribbed for the first 60 or 70 feet. These shafts cost from $15.00 to $25.00 per vertical foot, the cost increasing with depth. Hoisting is by rope and steel bucket, and portable steam hoists of 10 to 25 horsepower, which lift from 750 to 1,500 pounds at a load. The accompanying photograph shows a typical shaft under construction.

Some of the more recent openings have been on the double-compartment plan, with self-dumping skips for handling the ore.



A Sullivan Drill on a long column in a high face of ore.



Shaft of the Columbia Zinc Co., north of Joplin.

Machine drills are employed for shaft sinking, putting in a round of 15 to 20 five-foot holes, depending on the hardness of the ground. When ore is reached the working face is advanced in all directions from the shaft. No timbering is needed, but pillars are left at intervals to support the roof, which is very firm. The face is rarely advanced more than 300 feet from the shaft foot, new shafts being sunk when this stage is reached.

In following the ore faces, the drills are mounted on columns and usually put in a round of five eight- to ten-foot holes, which are shot with 1½-inch 40 to 50 per cent. dynamite. Fifty feet of holes is considered a good day's drilling (ten hours) for a 3¼-inch air drill, and wil break 35 to 50 tons of ore. When the ore faces are high, 20 or 25 feet, as frequently occurs, drills mounted on columns drive a heading in the upper part of the stope, and the bench below is lifted by drills on tripods which put in horizontal holes, as illustrated on page 156.

MINING MACHINERY.

Drills of all standard makes are in use in the district. The Sullivan machines, sizes "UC" (2¾-inch) and "UF-2" (3¼-inch), are preferred by many companies on account of their high drilling speed and low cost for maintenance, as compared with other makes. There are over 1,000 of these drills in the district. Air compressors are largely of the Sullivan class "WB-2" straight line simple steam and two-stage air type, in sizes ranging from 558 to 1,380 cubic feet. There are also a number of belt-driven Sullivan compressors of the straight line two-stage pattern, and a few duplex machines. One of the latter is illustrated on page 156. A Sullivan machine recently developed, which is meeting with favor on account of its high fuel economy and convenience, is the class "WC" straight line tandem compound Corliss two-stage air compressor, illustrated on page 164.

MILLING PROCESSES.

The ore from the mines is concentrated in jigs, and the tailing upon tables. A complete and well-illustrated article describing the details of Joplin milling practice will be found in the *Engineering and Mining Journal* of July 13, 1907.

A typical mine and mill.

Allowing for all actual expenses of operation, the preparation of a ton of ore ready for the smelter costs the small operator between $20.00 and $30.00. Royalties, taxes, and all other charges added raise this amount from three to five dollars per ton, but some of the larger companies, who own the source of production as well as concentrating plants, can put the ore in the bin at a total cost of about $15.00 per ton.

In line with the tendency towards economy in operation are the introduction of electrical energy from central water-power plants and the piping of natural gas to the mines from the Kansas fields.

The ore is reduced to metallic zinc and lead by smelters in Kansas, Illinois, and New Jersey.

THE HUDSON RIVER CROSSING OF THE NEW YORK WATER SUPPLY AQUEDUCT.

By Joseph H. Brown, Jr., M. E. *

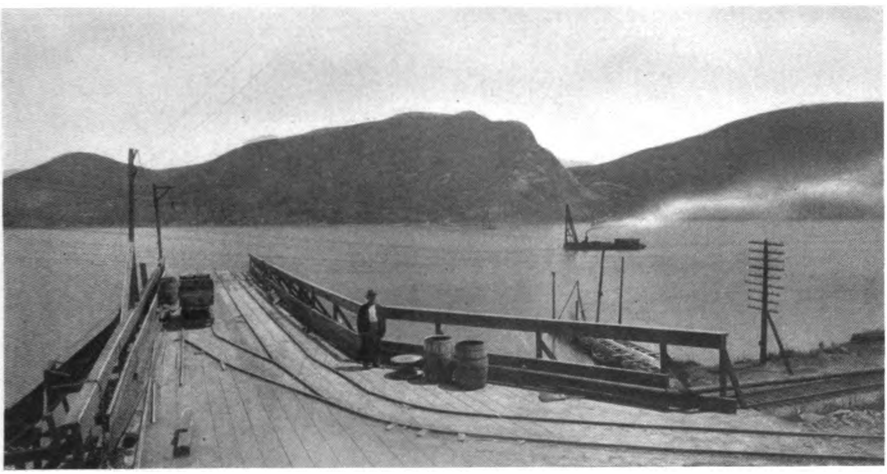
The site selected by the New York City Board of Water Supply for the crossing of the Hudson River by the new aqueduct, which is to supply New York City with water from the Catskills, is just south of Cornwall, New York. The present scheme is to make the crossing by means of a tunnel through solid rock under the river; but before beginning actual construction, elaborate experimental work is being done for the city by the Cranford Company of Brooklyn.

The river at this point is approximately 3,000 feet wide and the depth of water at the middle is about 40 feet. Test borings with prospecting drills from scows on the river show, however, that the rock bottom is far below the 40-foot level, and at the time of writing rock has apparently been reached at a depth of a little over 500 feet below the surface of the water.

The object of the experimental work now being done by the Cranford Company is to show conclusively whether solid rock exists beneath the river at a depth not too great for practicable tunneling. Briefly, the plan is to sink two vertical shafts, one on each side of the river, and from chambers at the bottom of these shafts drive horizontal diamond-drill boreholes underneath the river. The depth of these shafts will depend upon the results obtained from the vertical test holes made from the surface of the river, and judging from present indications, they will probably go down about 600 feet below the water level.

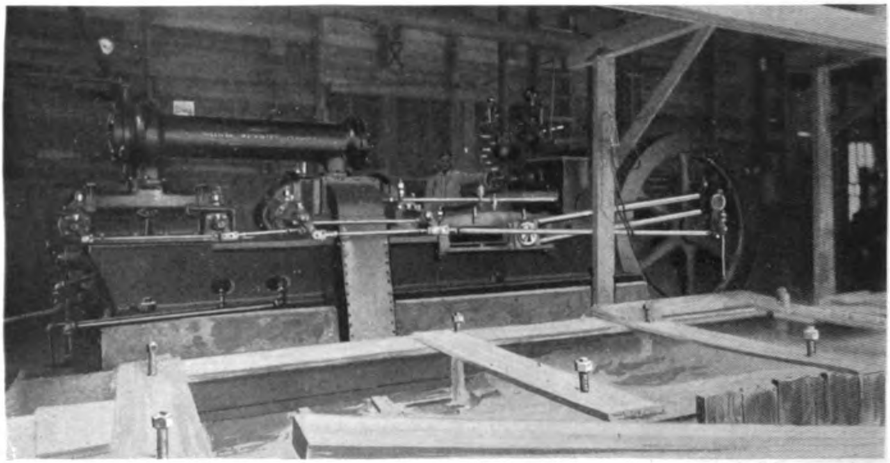
The shaft on the Cornwall side of the river, the west shore, is rectangular, 17x11 feet 6 inches. The bank here slopes abruptly to the river and the head of the shaft is 60 feet above the water level and 200 feet inland from the water's edge.

At present the excavated rock is hoisted to the surface in a steel bucket,



The proposed site for the aqueduct crossing; Mount Storm-King, from the Cornwall shaft.

* 42 Broadway, New York.



The Sullivan Air Compressor at Storm-King shaft. The foundation for the second machine is seen in the foreground.

then carried in small cars over a wooden trestle across the tracks of the West Shore Railroad, where it is dumped into cars below. Regular mine cages will soon be installed to take the place of the bucket.

Sullivan "UF-2" (3¼-inch) drills mounted on 5½-inch single-screw shaft-bars 11 feet long are in use here, and air is supplied by a Sullivan "WB-2" straight line two-stage compressor with a capacity of 1,160 cubic feet per minute.

The shaft on the east shore, at Storm-king, is circular, 17 feet in diameter, and located on a small spur of land between the New York Central tracks and the river. A part of the bank was excavated by open-cut work, so that the collar of the shaft is only a few feet above the water. As at the Cornwall shaft, a steel bucket is used for hoisting purposes, but this also will soon be replaced by cages.

Sullivan "UF-2" (3¼-in.) and "UH" (3⅝-in.) drills mounted on tripods are used here, and air is furnished by a Sullivan compressor of the same size and type as that at the Cornwall shaft. Owing to the formation of the shore, the power plant is located 1,100 feet south of the shaft. Another Sullivan compressor, a duplicate of those already in operation, will soon be installed at this point.

The rock on both sides of the river is a granite, but on the east shore flint occurs in large quantities, making extremely hard drilling. So far, scarcely any water has been encountered, though both shafts are some distance below the level of the river. Indeed, at the Cornwall shaft it was found necessary to pipe water into the shaft to supply the drill runners with a sufficient amount.

The work is going on continuously, night and day, in three shifts of eight hours each. Both shafts will soon be lighted by electricity, the plant on the east shore being already in operation.

When the shafts have reached the desired depth, four Sullivan "B" diamond core drills will be installed—two on either side of the river. Each drill will put in horizontal holes 1,500 feet long, and from the cores taken from these holes the Board of Water Supply engineers will be able to determine exactly the formation of the river bed at all points of the proposed crossing.

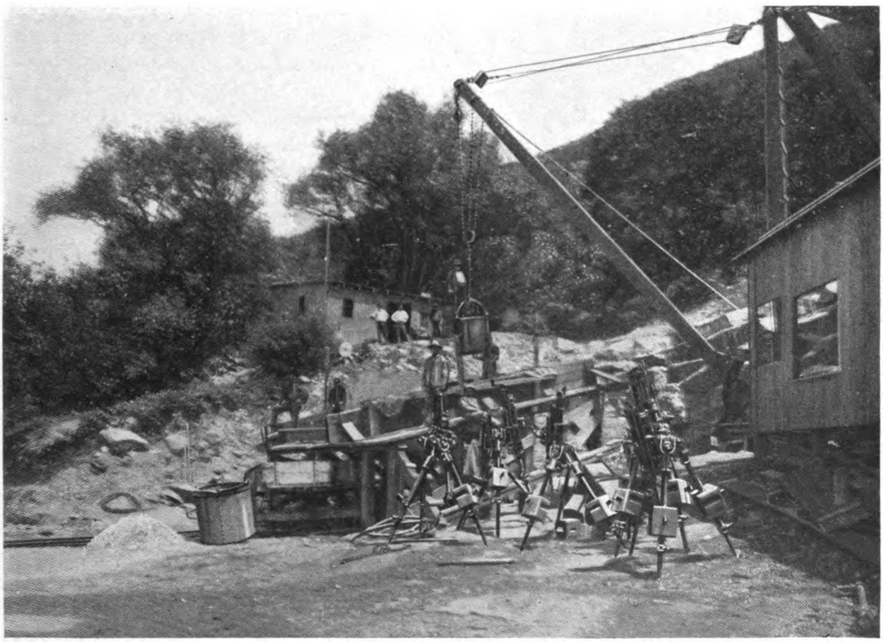
A STRAIGHT LINE CORLISS AIR COMPRESSOR.

By H. A. Wainwright, M. E.*

All engineers recognize in the Corliss engine the most economical means of compressing air by steam power. In the cross-compound type, one horsepower may be produced on from 14 to 16 pounds of feed water per hour, when running condensing, or 20 to 23 pounds non-condensing. But the price of the Corliss unit appears large to many operators, even in regions where the cost of the fuel saved would, in a short time, pay for the entire machine. Slide-valve compressors are therefore often installed, which require two to three times as much fuel to do the same work.

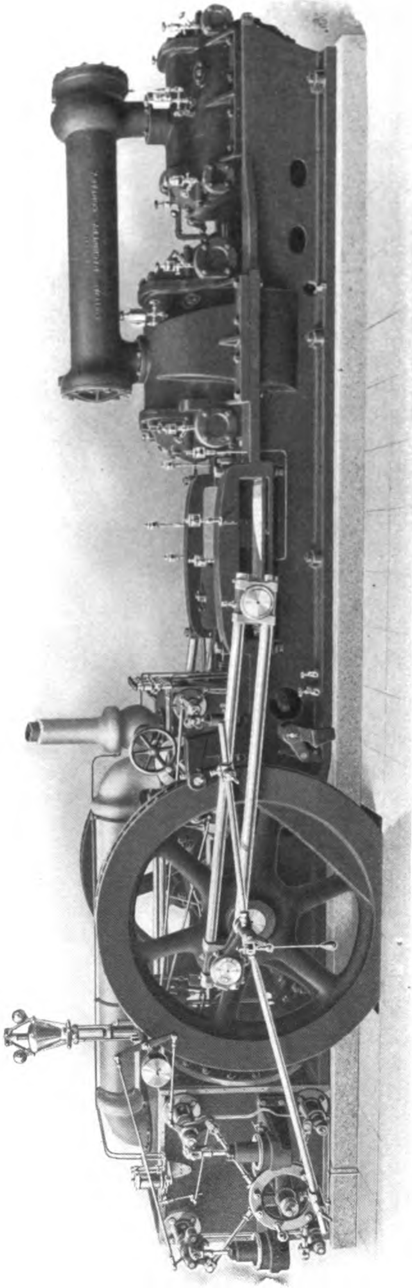
The development of an air compressor combining high steam economy with moderate price has advanced but slowly. In some cases the principles of good mechanics have been distorted to the sacrifice of durability, ease of action, and mechanical efficiency, in order to reduce construction costs. In others, various substitutes for the full Corliss valve gear have been offered. It is conceded that some of these compromise machines may fairly claim a certain degree of economy in operation, and that when a test is made under ideal running conditions, they make a good showing as compared with a Corliss compressor.

The conditions of every-day operation, however, are not one time in a hundred like those prevailing in a test. In the latter case, the steam pressure, air pressure, and speed are all constant, whereas in the former the fluctuation in any or all of these factors is likely to be extreme.



Sullivan Drills at Storm-King shaft, on the surface, during a blast.

* 1170 West Lake St., Chicago.



Sullivan Corliss Straight Line Air Compressor, with tandem compound steam cylinders and two-stage air cylinders.

Sometimes these extremes oppose one another, sometimes they may be high or low together.

It is on account of this fluctuation that the Corliss compressor uses so much less coal in the course of a day's run. Its valve gear brings the cutoff in both the high-and low-pressure steam cylinders under the automatic regulation of the governor. There is no wire-drawing of the steam, nor is there throttling action at any time.

A NEW TYPE.

A compressor has at last been designed, however, which embodies the economy of the Corliss cross-compound type in a form which permits moderate price without the sacrifice of good engineering. The credit for this achievement belongs to Mr. S. T. Nelson, one of the mechanical engineers of the Sullivan Machinery Company, and the superintendent of its western factory at Chicago. The new machine, known as the class "WC," is described as a "tandem compound steam, two-stage air, Corliss straight line compressor." To put it differently, tandem compound steam cylinders with full Corliss valve gear on both have been attached to the fly-wheel end of the standard Sullivan two-stage straight line compressor, the high-pressure steam cylinder occupying the same position as the single Meyer valve cylinder of the "WB-2" machine. The photograph shows the arrangement.

DESIGN OF STEAM CYLINDERS.

The high-pressure steam cylinder is of special design, to make room for the Corliss valve bonnets and dash pots between the cylinder and fly-wheels, and in order to do this the steam chest is offset to one side. The dash pots for closing the steam valves are set directly on the main frame and the motion rods for operating the exhaust valves are arranged in the usual way except that they are longer. Back bonnets are provided as usual and the frame is so designed that either one or all of the steam or exhaust valves may be removed without disturbing the valve setting. The low-pressure steam cylinder is attached to the end of the frame by means of rigid distance pieces. The bottom feet of this cylinder are on the same level with the bottom of the main frame, and its weight is supported by an extension of the foundation. Practically the same pattern is used for making this cylinder that is used for the Sullivan cross-compound Corliss machines. It embraces all of the regular valve gear usually furnished with the latter type of machine.

ARRANGEMENT OF WORKING PARTS.

There are no adjustments between the fly-wheels and the steam cylinders which require attention while the compressor is in operation. The piston-rod stuffing boxes are packed with fibrous metallic packing, which needs care only occasionally. The main bearings and other parts, which cannot be oiled by hand while the machine is running, are lubricated by a system of pipes leading from a cluster of oilers mounted at a convenient point, so that the engineer can tell at a glance when any one of them is empty.

The eccentrics for operating the valve gear on both the high-pressure and low-pressure steam cylinders are located on the crank pin on the outside of the fly-wheels so that they are easily accessible. The eccentrics, rocker arms, valve stems, and all connections located between the fly-wheels or between the main bearings on the "WB-2" type are dispensed with in the class "WC." The governor pulley is all that is located on the shaft in their place. The removal of these parts allows the use of two piston-rods between the high-and low-pressure steam cylinders, which are necessary in order to straddle the crank shaft, the latter retaining its original position in line with the cylinders.

STEAM REGULATION.

The governor is located on a separate mounting and is a combined speed and pressure regulator. In appearance it is of the Corliss fly-ball type, but it operates in unison with the pressure attachment. Either part may also operate independently of the other when necessary.

The exhaust steam from the high-pressure cylinder is carried around the outside of the cylinder barrel to the top by a passage cast with the cylinder, and discharges into a covered receiver pipe, extending from the top of the high-pressure to the top of the low-pressure cylinder.

AIR EFFICIENCY.

From the standpoint of air efficiency, this compressor takes the same high rank as the class "WB-2" machine. (See illustrations on pages 162 and 167.) The inlet valves on both low-and high-pressure cylinders are of the semi-rotary pattern, positively driven by motion rods from an eccentric pin on the engine fly-wheel. The action of these valves permits the cylinder to fill itself completely at each stroke, with air at the temperature of the atmosphere, and there is no wire-drawing or leakage. The discharge valves are of the automatic poppet type, so arranged as to reduce clearance losses to a minimum. They are removable by hand, together with the valve seats, so that the maintenance of a perfect fit is a simple matter.

The ideal of isothermal compression is closely approximated in these machines by means of unusually adequate cooling apparatus. This consists of heavy water jackets on the air cylinders, and an inter-cooler of ample proportions, containing copper water tubes, across which the air must pass several times in its course from the intake to the discharge cylinder.

The class "WC" compressor is built very substantially, being self-contained on its heavy frame and on the distance pieces connecting the two steam cylinders. These parts are sufficiently massive to sustain the low-pressure cylinder themselves, without the aid of foundations, if such a necessity should arise.

The straight line type unites with its well-known advantages of engineering excellence the features of low weight, simplicity, and minimum foundations, as compared with duplex machines. These qualities render it possible to sell the class "WC" compressors at a comparatively low price, to transport them readily and at small expense, and to erect them without elaborate and costly foundations at the desired site. They are built at present in sizes ranging from 909 to 2,450 cubic feet of free air per minute.

COAL MINING IN THE INDIAN TERRITORY.

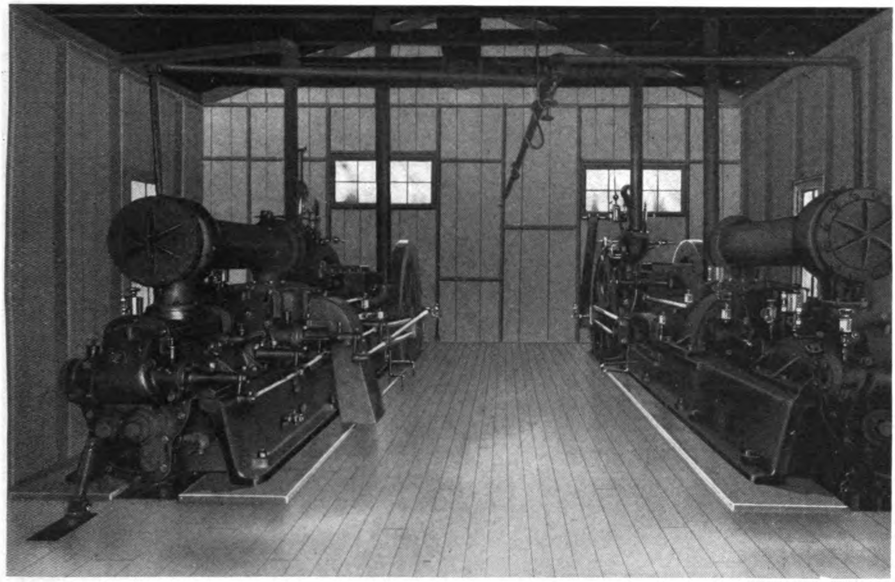
By George W. Blackinton, M. E.*

The Indian Territory coal field lies to the west and southwest of Fort Smith, Arkansas, and is embraced in a circle 100 miles in diameter, of which McAlester is the geographical and mining center. Henryetta on the northwest, Lehigh and Coalgate to the southwest, and Sans Bois and Poteau to the east are the limits of the district.

* Missouri Trust Building, St. Louis, Mo.

EXTENT OF THE INDUSTRY.

The industry is comparatively new. Over 75 per cent. of the mines have been opened since 1900, and of these many have, until recently, been worked in only a small way from the outcrop. The following table shows the production by years:



Sullivan Air Compressor Plant of the Hailey-Ola Coal Co., at Haileyville, I. T.

1896	1,366,646	short	tons.
1901	2,421,781	"	"
1902	2,820,666	"	"
1903	3,517.388	"	"
1904	3,046,539	"	"
1905	2,970,661	"	"
1906	2,859,450	"	"

The decrease in production during the last two or three years is attributed to the competition of oil, used as fuel by the railroads, manufactories, and other users of steam in this section. The number and extent of the openings (over 100) permit a much heavier output if a market were assured.

Nearly all of the openings are slope mines, although some are worked from shafts as well. The deepest shafts are on the Lehigh vein at Coalgate and Lehigh, where there are several over 600 feet deep. The McAlester and lower Hartshorne veins near McAlester have been pierced at depths of 500 to 550 feet from the surface. The coal ranges in thickness from 2½ feet (at Henryetta) to six feet (at Wilburton), while the average height of vein is from 3½ to 4½ feet. The veins are tilted at angles ranging in various parts of the district from five to 50 degrees. Gas is frequently encountered, but is a serious factor, requiring the use of safety lamps, in only one or two instances.

MINING METHODS.

The coal is mined on the room and pillar system, and hand labor is responsible for more than 95 per cent. of the output, the coal being shot off the solid. It is hauled by mules on the levels, and by small compressed-air haulage engines on the slopes. The practice of "solid shooting" is both dangerous and uneconomical, since it shatters the coal unnecessarily, and when black powder is employed, not infrequently causes windy shots and serious gas explosions. Dynamite is replacing powder in some localities. In driving entries by hand, a cutting two or three feet deep is placed at the center of the working; holes for the cut shots are then drilled 18 inches to

two feet deeper than the cutting and loaded with five or six sticks of dynamite. The resulting explosion is too often more than the roof can safely bear.

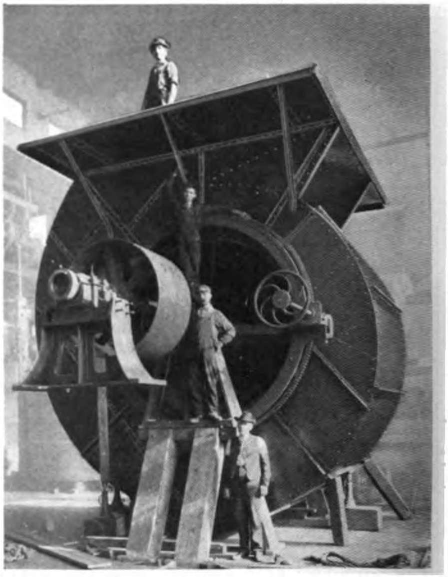
MACHINE MINING.

Mining machines are little used, for various reasons. In some mines the heavy pitch of the vein is prohibitive. Electric machines may be used with safety wherever open lamps are employed. but, as a rule, have proved a failure on account of the extra labor required to operate them on the steep inclines. When the pitch exceeds a few degrees, three to four men are needed to handle the ordinary chain breast machine. This was demonstrated several years ago in the Lehigh mines, in which a machine crew consisted of one runner, one shoveler, one man with a crowbar to keep the machine from sliding down hill, and a fourth man to move props, since the machines occupied from ten to twelve feet in front of the coal.

An exception to the rule is found in the Sullivan continuous cutting type, which crosses the entire face under its own power on a feed chain, at one operation. This machine also requires only five or six feet in front of the coal while cutting, so that the third and fourth men are eliminated. It has worked with success in various parts of the Territory on pitches up to 25 degrees, when cutting across the vein, and on pitches of 12 degrees when cutting up the vein.

The machines of this type hitherto used are electric, hence their employment has been restricted to mines in which naked lamps may be carried. The manufacturers, however, are developing an air-driven machine which should find general acceptance in this field.

Pick machines, operated by air, are available for mining in rooms in the Henryetta district, where the vein is flat, and in some of the mines at Wilburton, in which the rooms are driven across the pitch. The general practice in this field, however, is to drive the rooms up the pitch, and, under these conditions, pick machines cannot be used to advantage. When the board is placed at the proper angle to enable the operator to handle his machine, a wasteful quantity of coal must be removed to secure an undercut of proper depth.

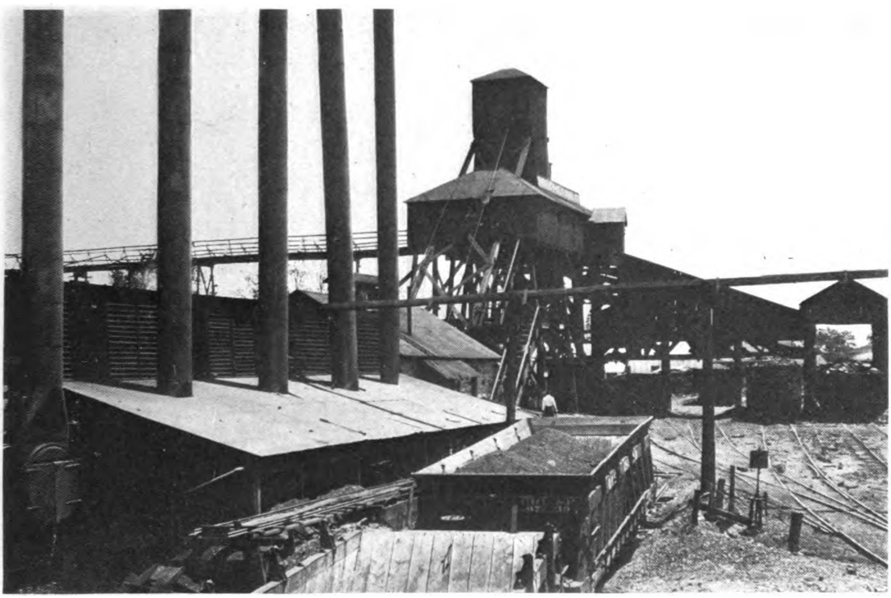


Sullivan Reversible Steel High-Speed Fan assembled before shipment.

MACHINE ENTRY-DRIVING.

The Sullivan pick machine has, however, been found particularly suitable for driving entries and slopes. Two men operate a machine and drive the entry, air course, and cross-cut, loading out their own coal. The entries are driven seven to nine feet wide and the crosscuts six or seven feet in width. This enables development to be pushed ahead more rapidly than by hand work. Each place is cut and loaded every shift, moving forward four and one-half to five feet. The men are paid on a tonnage basis, the price being fixed between the machine loading rate (40 cents) and the pick rate (72 cents).

This method of development not only gives the operator better coal from the entries, but does away with heavy shots and the resulting dangers described above. Only a small fraction of the



Power-House, Head-Frame, and Tipple of the Hailey-Ola Coal Co., No. 1 Mine, Haileyville, I. T.

amount of the explosive used in hand mining is needed to bring down coal undermined by the machine.

This system is in successful operation at the No. 1 Mine of the Hailey-Ola Coal Co. at Haileyville. The Sullivan "class 2" 700-pound pick machines are supplied with air from two Sullivan 1160-foot class "WB-2" straight line two-stage air compressors. These machines, shown in the illustration on page 167, also furnish air for the mine pumps in this mine and at the No. 3 opening, a mile away; for the hoisting engines at both mines; the shop engine, the box car loader, and the direct-connected engine for the new Sullivan 10-foot high-speed reversible, steel ventilating fan (see page 168) being built for No. 3 mine. This last use of the air will eliminate the necessity of an isolated steam plant to run the fan.

Ventilating practice is tending toward the installation of high-speed fans, capable of producing a higher water gauge and thus of effectually removing the foul air, gas and powder fumes from the thin veins, as the mines are opened up further.

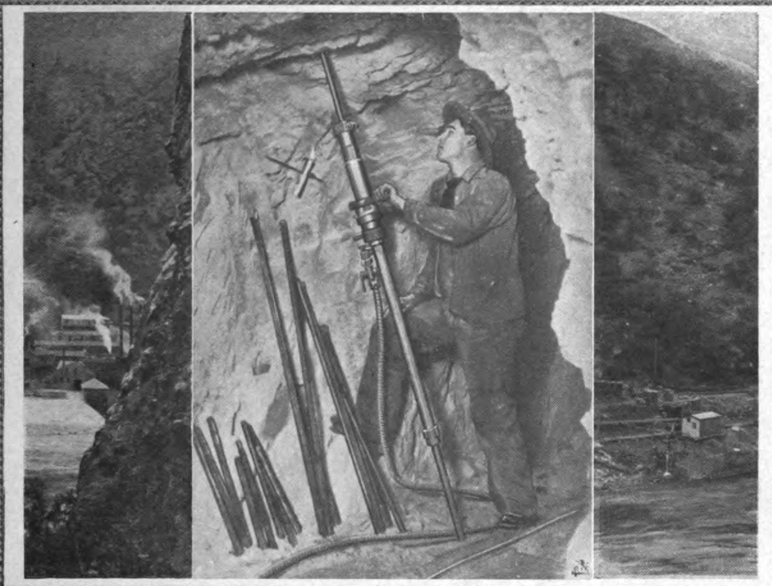
Machine mining in this field is expected to increase as the mines are developed, and as the miners come to realize that they may secure better pay with less labor and danger by the use of machines than by shooting from the solid. The use of machines in this field will be of two classes, as outlined above, requiring separate and distinct machines. First, the driving of entries and slopes with pick machines; and second, the use in rooms of electric and air chain machines of the self-propelling continuous cutting pattern.

There should be a good demand for the last named type, owing to its ability to operate on considerable pitches, its safety from gas, and to the fact that many of the operators already have air-power plants installed for other purposes.

The author is indebted to Mr. M. K. McCoubrey, superintendent of the Hailey-Ola Coal Company, for the information concerning entry-driving used in this article.

MINE AND QVARRY

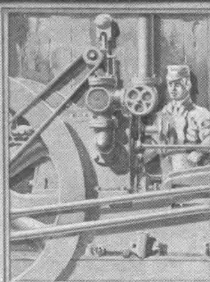
VOL. II. NO. 3. FEBRUARY, 1908.



HAMMER ROCK DRILLS

MISSOURI BUILDING STONE

LONG-WALL MINING IN PENNSYLVANIA



PVBLISHED BY THE SVLLIVAN MACHINERY CO. RAILWAY EXCHANGE BVILDING, CHICAGO

TABLE OF CONTENTS

Editorial 169

Mining with Hammer Drills 171
M. G. DOLL

Carthage Limestone 179
R. S. STRONG

Adaptability of Hammer Drills 183
G. H. GILMAN

Diamond Drilling at Mapimi 184
J. F. BENNETT

New York, New Haven and Hartford Railroad Tunnels 187
H. N. HARDING

Mechanical Conveyors as applied to Long-Wall Mining 193
J. I. THOMAS

MINE AND QUARRY

Vol. II. No. 3. FEBRUARY, 1908

A Quarterly Bulletin of News for Superintendents, Managers, Engineers and Contractors.

Published by the Advertising Department of the Sullivan Machinery Company.

Address all Communications to MINE AND QUARRY, Railway Exchange, Chicago. Sent to any address upon request.

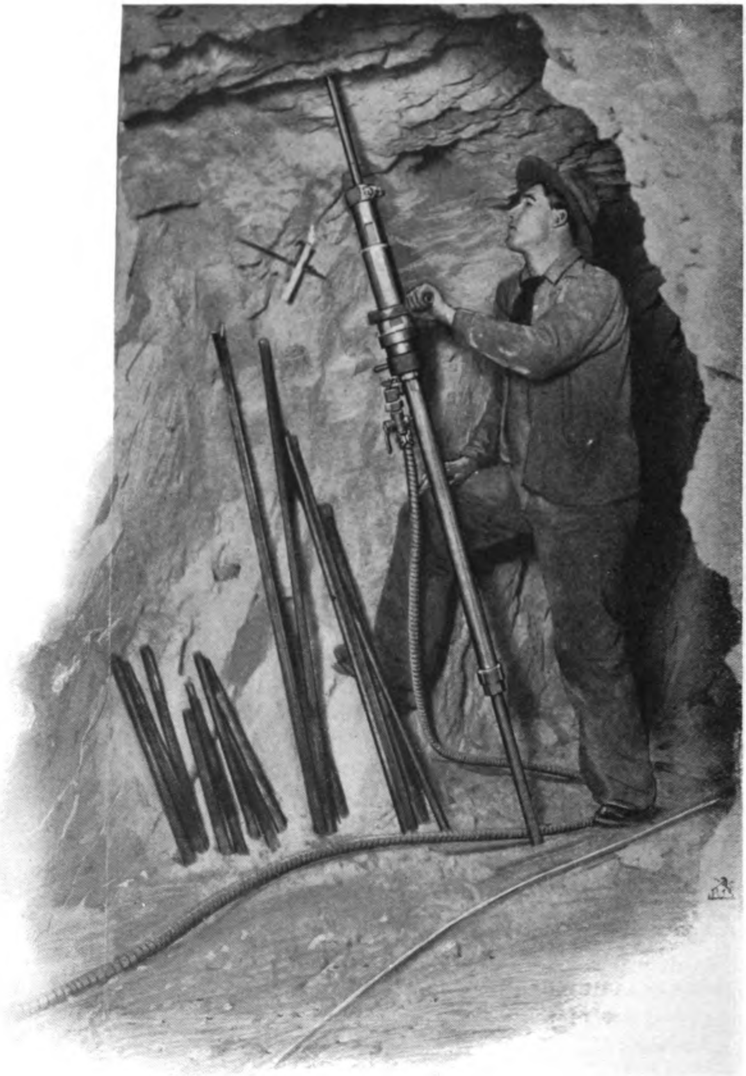
Readers are requested to notify MINE AND QUARRY of any correction or change in address.

Readers who have copies of the August, 1906, issue, for which they have no further use, will confer a favor by mailing them to Mine and Quarry. A price of 10 cents per copy will be paid for these magazines.

An example of the intelligent and consistent use of diamond core drills, as an adjunct to mine development, is described on page 184. There are many other districts in which diamond drill exploration is a part of the routine of mining, and many more still in which it should be, to avoid waste in development. The use of these drills should not stop with the discovery of ore from the surface. It should be constantly maintained, probing every foot of ground in advance of the tunnel, shaft, or cross-cut. In this way the element of chance is removed, and the mine manager knows, before driving his workings, the location, amount, and character of the ore that is ahead of him, and the cost of reaching and mining it.

After several years of experimental work, the field of air hammer drills in mining appears to be largely reduced to a single important function, that of drilling overhead holes in stopes and of driving raises. In this department, these drills, fitted with the newly invented automatic air feed, are displacing the 2-inch and 2¼-inch piston drill, mounted on a bar or light column. In addition to their superior convenience and ease of manipulation and movement, they show relatively greater drilling speed and lower air consumption, which secure to them high comparative economy. For drifting and for sinking, under most conditions, and, in general, for work in which the cuttings will not fall from the holes by gravity, the piston drill maintains its place, and is likely to do so until some practical method is devised for keeping clear of dust or sludge the holes drilled by the hammer type of machine.

A third class of work, not so important as the first two, is being appropriated by the hammer drill; namely, trimming up walls, roofs, and floors of workings, cutting hitches for timbers, and drilling pop-holes in large fragments of rock or boulders. For such purposes, formerly accomplished by hand, the hand hammer drill, similar to the type used in quarries for "plug" holes, is proving valuable. A special article on the advantages of air hammer drilling, printed in this issue, gives some interesting data on work in western mining camps.



Sullivan "D-21" Hammer Drill in operation

MINING WITH HAMMER DRILLS.

DEVELOPMENT, METHODS, COSTS.

By M. G. Doll.*

Within recent years the increasing volume of production in metal mines, the comparative scarcity of labor, and the necessity for curtailing every expense connected with the mining of the lower grade ores, in order that a profit may be shown, have caused the introduction of lighter and smaller rock drills, for stoping and other light work. These drills not only replace heavier machines, but perform much service previously accomplished much less rapidly and at higher cost by hand.

The smaller piston drills, with two-inch and 2¼-inch cylinders, were first introduced for this work, and filled its requirements to a certain extent. These machines in most cases only required one man for their operation, and the power factor was materially reduced, but there still remained a number of difficulties with which to contend. Much time was consumed in setting up and tearing down the drill, and in moving it from place to place. After a "set-up" had been made, a number of holes had to be drilled radiating from a common center, in order to save time, so that each hole was not in the ideal position for breaking the rock in the most economical manner. Where the pay streak was narrow, a stope wider than necessary was required to make room for the drill mounting, involving the breaking of waste rock, which became mixed with the ore, causing an increase in the cost of dressing the mineral.

EARLY HAMMER DRILLS.

To meet these conditions, there appeared a tool which was an adaptation of the pneumatic hammer. This tool went to extremes in the matter of weight and air consumption, being designed to weigh only 15 to 20 pounds, and to use in the neighborhood of 25 cubic feet of free air per minute. The adoption of this tool, however, progressed more slowly than its early performance appeared to promise, for two reasons: First, the machine was put on the market for use in all forms of rock-breaking in mines, for sinking shafts, and driving drifts, as well as for stoping and raising. In sinking and drifting with this drill, it was necessary to provide some mechanical means for removing the rock cuttings from the drill-hole. To accomplish this, a hole about 3/16-inch in diameter was drilled in the steel. Through this a portion of the exhaust air from the machine was led to the cutting face of the bit, to blow the cuttings out of the hole. This caused so much rock-dust that it was disagreeable to the runner.

Second, as this drill was used without a mounting, its efficiency depended on the ability of the operator to hold it to its work. When holes were drilled in such a position that the operator could not put his weight behind it, the weight of the machine and its vibration prevented its practical use. The most important work which this drill accomplished was to prepare the way for a new type of hammer drill.

PRESENT TYPES.

The machines now in use are made much heavier than at first thought advisable, and manufacturers have gradually increased the size and the air consumption, until a very powerful drill has been built, which has overcome many of the difficulties in the original pneumatic hammer machine, yet is comparatively light, and much more economical than the piston drill, for the work to which it is adapted.

*Denver, Colo.

STOPING DRILLS.

The use of air hammer drills in mines is at present confined chiefly to overhead drilling, for which they have shown themselves especially adapted. When flat holes are necessary, or holes from which the cuttings will not fall by gravity, the 2¼-inch piston drill is still the most efficient tool. In nearly all mines, therefore, there is a legitimate field for each machine, and each must be restricted to that field to secure economical results.

OPERATING ADVANTAGES.

The air hammer drill cannot drill a hole of as large diameter as the 2¼-inch piston drill. This necessitates using less powder in each hole, and thus the drilling of more holes to break the rock. Its advantages, however, lie in the ease and rapidity with which it is handled, and in the fact that each hole may be put in in the exact direction and position desired, so that much less powder is needed to cause the rock to break properly. In the case of the piston drill all the holes radiate from a common center, so that more powder is required in some of the holes, simply because they are not in the ideal position for the blast. By means of this drill, narrow veins are opened only sufficiently to permit the drillman to enter. This also gives sufficient room for the operation of the machine. This has been demonstrated in the Cripple Creek district in Colorado, where the veins to be stoped out carry thin values and the neighboring rock is often barren.

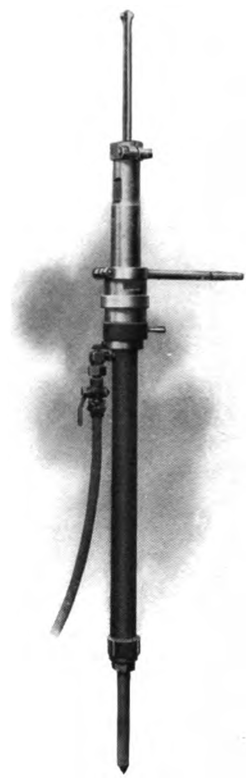
DEVELOPMENT OF THE SULLIVAN DRILL.

About the time of the production of the first pneumatic hammer mining drill, the Sullivan Machinery Company introduced its "plug hole" drill, mentioned below, into Eastern quarries, for "plug and feather" work in breaking dimension stone. This machine proved to be so far superior to any other machine of the type that a series of experiments was begun to adapt the principles of this drill to the conditions peculiar to mining.

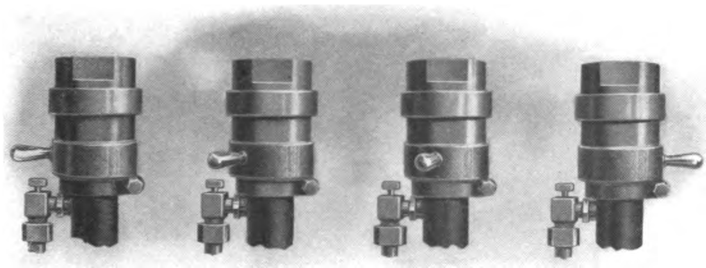
These experiments were very thorough, and were conducted in various western mines, under the most severe conditions to be found. The standard drill, type "D-21," which has been developed as the result, is noteworthy on account of its high drilling speed, its economy of power, and the excellence of its materials and construction, which have reduced repair costs to a minimum.

FEATURES OF THE "D-21" DRILL.

The machine is mounted on a pneumatic cylinder and piston, which form a part of the drill, and serve the double purpose of mounting and of feeding it



Sullivan "D-21" Air-Feed Hammer Drill—For drilling up-holes only for raising and back-stoping.



Throttle in first position. Air shut off from hammer and feed. Feed pressure released.	Throttle in second position. Air admitted to feed piston, forcing drill up to its work. Hammer still shut off.	Throttle in third position. Hammer running slowly. Feed on.	Throttle in wide-open position. Hammer running full speed. Feed on.

forward against the rock. The throttle device is so arranged that the pneumatic feed and the hammer are controlled by one handle, attached to a knurled eccentric collar, actuating a spool valve. This device, for convenience, is provided with notches or clicks. When the collar is turned to the first notch, the air is admitted to the feed, raising the machine against the face ready for drilling.

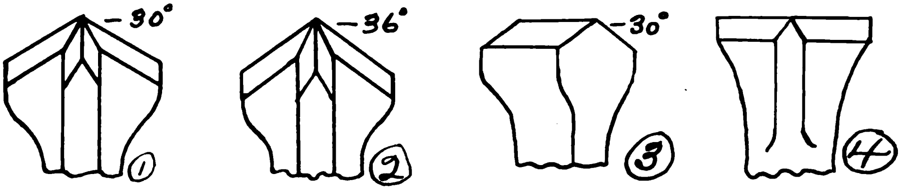
On turning the handle to the third click, the hammer runs slowly, and full speed is reached at the fourth position of the throttle. In stopping the machine, for changing steel, the throttle is reversed to the second notch. This stops the hammer, but the drill is held against the face by the air in the feed cylinder, until this also is shut off by bringing the throttle back to the starting point. There is practically no wear on the parts of this throttle, and nothing to get out of order.

In the automatic air feed, the feed cylinder is attached to the drill proper, and the feed piston moves out at the bottom of the cylinder as the drill bit advances into the rock above. This permits a strong and durable connection between the feed cylinder and drill head. The feed piston itself is also provided with an automatic locking device which holds it in the feed cylinder while the machine is being moved from one place to another.

The exhaust is so arranged that the air is always thrown away from the work and from the stream of cuttings dropped from the drill-hole, so that the dust from the cuttings is not stirred up or mixed with the air of the mine. The cuttings consequently pour from the drill-hole in a small continuous stream. By this arrangement the dust from this drill does not inconvenience the drillman. There are no nipples or exhaust ells to come loose or break off under the vibration of the drill.

STEEL.

The form of steel which is the most practical for use with this machine is the one-inch heavy-ribbed cruciform solid steel. The shape of the bit is largely determined by local conditions. The following table, with illustrations, shows the results obtained by experiments on four different designs of bits, which were operated under the same conditions as far as possible, in medium hard rock.



Shapes of Bits for stoping drill.

TABLE No. 1.

Shape of Bit	Duration of Runs	Diameter of Hole	Average Depth of Hole	Air Pressure	Remarks
30 Degrees No. 1.	4 min.	1⅝"	11¼"	94 lbs.	Spots holes easily.
	4 min.	1⅝"	10"	85 lbs.	Easy of rotation.
36 Degrees No. 2.	4 min.	1⅝"	8"	94 lbs.	
	4 min.	1⅝"	6"	85 lbs.	
30 Degrees No. 3.	4 min.	1⅝"	12"	94 lbs.	Gauge dulled rapidly.
	4 min.	1⅝"	10½"	85 lbs.	
No. 4.	4 min.	1⅝"	11"	94 lbs.	
	4 min.	1⅝"	9¾"	85 lbs.	

AIR CONSUMPTION.

The best air pressure to be used, considering the breakage, wear and tear on machine, as well as efficiency of drilling speed, is in the neighborhood of 90 pounds. The actual air consumption of this type of machine is rather hard to determine accurately, as it is subject to many varying conditions. However, the following figures may be of some service. In the Cripple Creek district in Colorado, where the cost of coal is from $5.00 to $6.00 per ton at the mine, and engineer's wages from $4.00 to $5.00 per shift, custom has established the following schedule of prices charged to leasers buying air—namely, $1.50 per drill shift for air hammer mining drills, and $2.50 per drill shift for 2¼-inch piston drills. However, in this schedule the cost for air hammer mining drills is comparatively high on account of the greater drilling time in each shift, because less time is occupied in making set-ups and changing steel. Roughly speaking, the air consumption of the Sullivan "D-21" drill with two-inch cylinder is about one-half that of the Sullivan 2¼-inch piston machine.

DRILLING COSTS.

From the date available, it is rather difficult to form any accurate tables for general use, as to the costs of mining with the air hammer mining drill, for the reason that these cost tables are governed entirely by the conditions prevailing in each mine under which the rock must be broken. In order to arrive at any definite conclusions for forming a general table, it would be necessary to gather data covering a large territory and all the conditions of working, (such as labor, cost of power, materials used, kind of rock and formation,) determining the ease with which the rock may be shot, the dimensions to which the stope must be held in

order to curtail the cost of handling the spoil, the formation of the vein matter, and method of handling broken rock. All these factors tend to vary the cost of mining. However, the table below may be of some service, and may serve as a guide to determining similar work under other conditions.

The data were obtained from two mines in which the rock would be classed as fairly hard, and the labor of average ability, but the formation of such a nature that it was necessary to carry out the methods of mining in radically different manners. This caused quite a variation in the actual mining costs. In one case, 7/8-inch or hand steel, 35 per cent. dynamite was used for blasting, while in the other case, the 1⅛-inch machine steel, 35 per cent. dynamite was used. It will be noted that in the case of the narrow stope the competing drill was unable to finish the amount of drilling requisite to break the stope to its full length in one shift, while in the case of the wide stope the Sullivan drill had a margin of two holes to its credit at the end of the shift, or a gain of one hour and 20 minutes per drill shift, based on the rate of drilling shown in the table. In the case shown in columns 1 and 2, on account of the extremely thin vein the stope was narrow, so as to cut down the cost of handling the spoil. If desired, double the width could have been broken with the same expense as to powder and drill-holes. This would double the tonnage and reduce the cost by one-half, or 12 tons of rock could be broken at a cost of $.665 per ton by the Sullivan drill, and $.742 per ton for the nearest contesting drill.

TABLE II.

TYPE OF DRILL.	SULLIVAN "D-21"	NEAREST COM'PTING HAM'R. DRILL	HAND DRILLING.	SULLIVAN "D-21"	NEAREST COM'PTING HAM'R. DRILL	2¼-IN PISTON DRILL
A. DETAILS OF PERFORMANCE.						
SIZE OF STOPE, FEET.	2½ x 13			6 x 8		
DEPTH OF HOLE, FEET.	3	3	3	4	4	4
DIAMETER OF HOLE, INCHES.	7/8	7/8	7/8	1⅛	1⅛	1⅜
Nº HOLES PER 8 HOUR SHIFT	14	12	2	12	10	8
DISTANCE DRILLED. FEET PER SHIFT.	42	36	6	48	40	32
CU. FT. ROCK BROKEN PER SHIFT.	97½	84	14	192	160	192
TONS BROKEN, AT 125 LBS. PER CU. FT.	6	5	.8	12	10	12
B. COST ESTIMATE BASED ON ABOVE PERFORMANCE.						
Nº HOLES NEEDED TO BREAK ABOVE STOPE	14	14	14	10	10	8 ⊙
FT. DR'L'G. " " " " "	42	42	42	40	40	32
CU. FT. ROCK BROKEN PER ROUND.	97½	97½	97½	192	192	192
TONS ROCK BROKEN, AT 125 LBS. PER CU. FT.	6	6	6	12	12	12
AV. AMUNITION COST PER HOLE	$ .173	$ .173	$ .173	$ .175	$ .175	$ .271
AV. WEAR ON STEEL & LOSS DUE BR'K'GE.	.005	.005	.005	.005	.005	.005
LABOR PER HOLE, AT $4. PER SHIFT.	.286	.334	1.50 x	.333	.40	.50
POWER " " " $1.50 PER DRILL SHIFT.	.107	.125		.125	.150	.312 ⁕
TOTAL COST PER HOLE.	.571	.637	1.678	.638	.73	1.088
" " " FOOT.	.19	.212	.559	.159	.182	.272
" " " ROUND.	7.98	8.904	23.478	6.36	7.28	8.704
" " " TON.	1.33	1.484	3.913	.53	.606	.725

NOTES:- THE COLUMNS "HAND DRILLING" & "2¼-IN. PISTON DRILL" ARE BASED ON AVERAGE PERFORMANCE UNDER SIMILAR CONDITIONS TO THOSE UNDER WHICH ACTUAL RECORDS SHOWN IN COLUMNS 1, 2, 4, 5 WERE MADE. ⊙ USING A LARGER AMOUNT OF POWDER.
X LABOR FIGURED AT $3.00 PER SHIFT.
⁕ POWER FIGURED AT $2.50 PER DAY.

The margin of advantage indicated by these figures for the Sullivan "D-21" drill needs a little emphasis to bring out its proper significance. In the case of the narrow working, the costs per ton show a difference of 10.4 per cent. in favor of this machine over the contesting drill, and of 66 per cent. over hand work. In the wide stope, the cost per ton of rock mined by the "D-21" type is 12.5 per cent. less than that shown by the contesting hammer drill, and 26.9 per cent. below the cost figure for the piston drill. Suppose that a production of 150 tons per shift is desired, and that the workings are of the same average size as that shown in columns 1, 2, and 3 in Table No. 2. If hand miners are employed, the cost per shift will be $586.95, or, for a year of 300 shifts, $176,085.00. If the "contesting drill" is adopted, the cost will aggregate $222.60 per shift, or $66,780.00 for the year. In case, however, Sullivan "D-21" drills are installed, the cost per shift will be $199.50, and per year $59,850.00, a saving of $116,235.00 per annum over hand work, and of $6,930.00 over the "nearest competing" machine. By similar figuring, based on an output of 300 tons per shift, the Sullivan "D-21" drill, in the second working assumed in the table, will show an economy per year of $6,840.00 over the nearest competing air hammer drill, and of $17,450.00 over the piston drill. These figures show the importance of even a slight superiority in working efficiency of the drilling machine.

The economical use of the hammer drill is not confined to stopes of the comparatively narrow widths assumed above. These machines will show results equally favorable in workings of any dimensions, such as the wide "square set" stopes used in the copper mines of Michigan, Arizona, etc., so long as the holes may be drilled at an angle of over 30 degrees with the horizontal, which will permit the dust to fall from the hole by its own weight.

No figures are shown for the piston drill in the narrow stope (columns 1 and 2). On account of the length of the stope to be drilled up to break an equal tonnage, a number of set-ups would have to be made, thus the actual drilling time per shift would be materially cut down, and as a consequence the cost per ton increased.

In a series of competitive tests held in the Cripple Creek district of Colorado, between the Sullivan "Class D-21" air hammer mining drill and other makes of machines, in which the tests in each case were run under like conditions as to air pressure, steel, character of rock, and ability of operator, it was found that the footage drilled in a given time by the Sullivan drill exceeded that of the nearest competitor by an average of about 20 per cent.

TABLE No. III.

Hole	Place	Rock	Air Pressure Pounds	Time Minutes	Inches Drilled by Sullivan D-21	Inches Drilled by Competitor	Sullivan Rate per Minute Inches	Competitor Rate per Min. Inches	Percentage in Favor of Sullivan
1	Mexico	Vesuvianite	75	10	25½	15⅝			
2	"	"	"	15	26⅝	19⅛	(Avg.)		
3	"	"	"	15	28¼	8	2.24	1.29	57.6
4	"	"	"	15	33½	25			
5	"	"	"	17	47¼	25 9/16			
6	Michigan	Jasper Iron Ore	60–65	same	32	16½	——	——	94
7	"	Medium Ore	88	3	54	35	18	12	50
8	"	Hard Iron Ore	——	6	45	18	9	3.6	250
9	"	"	——	9.5	45	29	4.7	3	55

The Sullivan "D-15" Drill cutting hitches in a shaft.

In the preceding table the first five holes were drilled in a Durango, Mexico, silver mine, in hard garnet rock, known as vesuvianite. The last four records were made on the Marquette iron range of Northern Michigan.

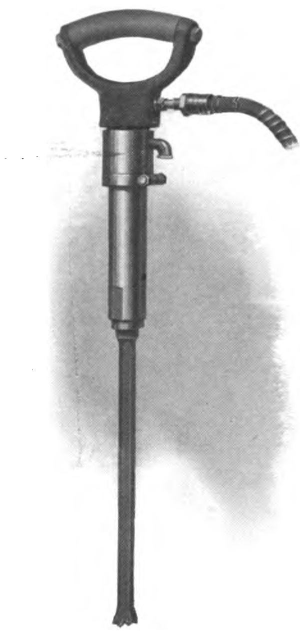
HAND DRILLS.

A second class of mining work in which air hammer drills are being profitably used is that of cutting hitches, trimming up the walls of workings, and drilling pop-holes to break up large boulders or fragments of rock.

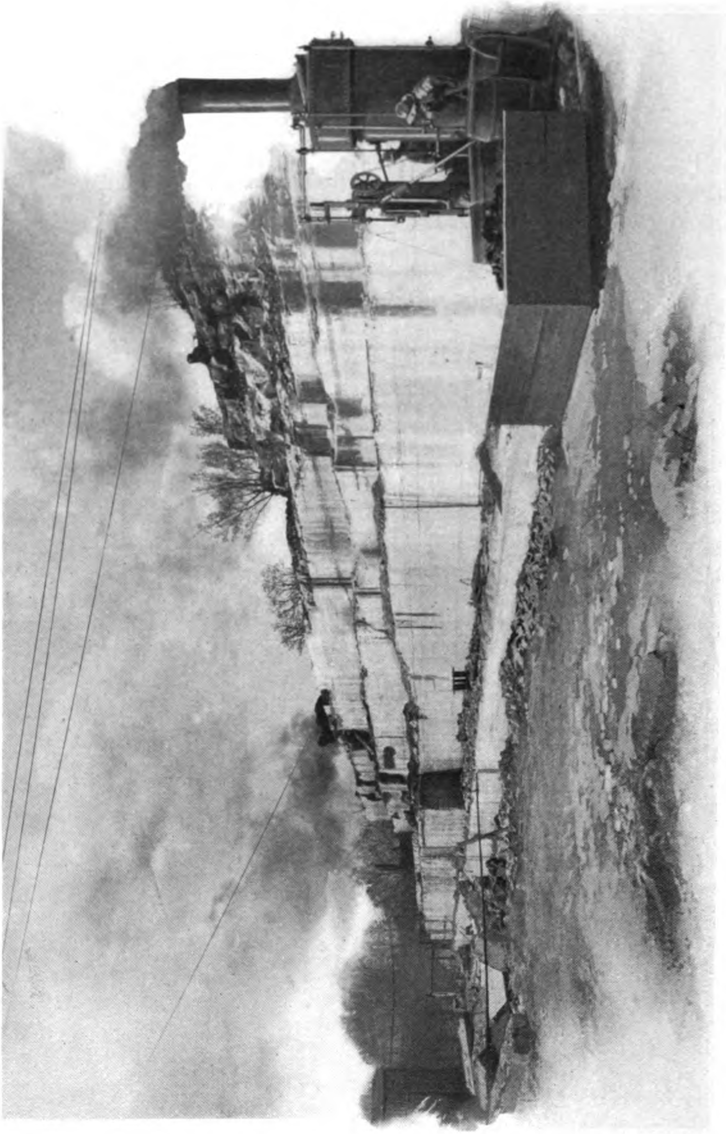
The accompanying photograph shows a Sullivan "D-15" drill, weight 18 pounds, cutting hitches in a shaft. The steel is hollow, and a portion of the exhaust air is used to clean the hole of dust and chippings. The throttle of this machine is within the handle and is opened by pressing the handle against the cylinder. When this pressure is relieved, the throttle automatically opens up and closes.

For cutting hitches, trimming up the roof, and taking up the bottom of workings for track-laying, the "D-15" hand drill is found invaluable by all mine operators who have installed them. Two hand hammer men are usually able to cut one pair of hitches for timbers in a shaft in a day's work. With the "D-15" drill, the same work can be done by one man in about two hours. It is readily seen that where there are a number of hitches to be cut, the saving is many times the cost of the drill.

In some mining camps considerable use is found for this machine in breaking up boulders. The old method was to use what is called a "dobe" or "dauber" shot. Two to four sticks of dynamite were placed on the boulder, covered with mud, and then exploded. The same work can be done on one to one and a half sticks of dynamite by drilling a six- or eight-inch hole in the boulder with the "D-15" drill. The saving, while not large in each case, is worth considering, when the amount of such work is extensive.



Sullivan "D-15" Hand-Feed Hammer Drill—For trimming.



Sullivan "Y" Channeler at work on a long face of Carthage stone.

CARTHAGE LIMESTONE: ITS PRODUCTION AND CHARACTERISTICS.

WRITTEN FOR "MINE AND QUARRY"

By R. S. Strong, M. E.*

LOCATION AND CHARACTER.

Carthage, Missouri, is situated in the southwestern portion of the state, about 20 miles from Joplin. It is in the heart of the lead and zinc mining district of the southwest, but is known as well for its deposits of limestone, which are extensively worked, for building purposes. The quarries cover a tract of about 200 acres, and produced in 1906 a total of three-quarters of a million cubic feet of stone.

The limestone is white, with a slight grayish tint, which is more restful to the eye than dead white. It is hard, being highly crystalline, and of a close, even texture. Analysis shows it to be almost pure carbonate of lime. Its components are:

Insoluble	0.69
Oxides of iron and alumina (Fe_2O Al_2O_3)	0.21
Carbonate of Lime ($CaCO_3$)	98.57
Carbonate of Magnesia ($MgCO_3$)	0.65
	100.12

(Figures of Missouri Bureau of Geology and Mines.)

Tests give a crushing strength of 20,261 pounds to the square inch at right angles to the bed plane, and of 16,551 pounds to the square inch when the stone is on edge. The absorption of moisture is practically 0. These features make Carthage stone very desirable for buildings, flagging and other uses requiring severe wear. The stone weathers imperceptibly, and when used for steps or floors shows wearing qualities equal to those of granite. Carthage, a city of 15,000 inhabitants, is largely built of this beautiful white stone, which is used for sidewalks and curbing, as well as for residences, business and public buildings. Carthage is for this reason one of the most physically attractive cities in the southwestern central states. Carthage stone has also been shipped to Kansas City, St. Louis, and many other points, where it is held in esteem. More recently the waste stone has found a large demand for crushing purposes. It makes excellent concrete, and is desirable on account of its whiteness. The pulverized stone finds a varied market, being used as a filler for paint and putty, a soap powder, an asphalt surfacer, a metal polisher, a fertilizer, and a food for poultry.

*265 Oak Street, Chicago.

GEOLOGY.

Geologically speaking, these deposits belong to the Burlington group of the Mississippian Carboniferous strata. They are composed of the remains of Crinoids and other shell-fish of the Silurian and Carboniferous epochs, whose forms may be readily traced throughout the beds. The ledges are horizontal and from three

Jasper County Court-House, Carthage, Mo.

A Sullivan "Y" Channeler putting in a deep cut.

to 12 feet thick, the thickness increasing with depth. The ledges are separated by mud seams, which in some instances have been washed out, leaving hollows and caves of great interest to the geologist. Beds of flint nodules occur at several levels in the formation, but do not occasion large waste, as the stone is usually quarried along them.

PRODUCTION: CHANNELING.

The first step in opening a quarry is to strip the stone of its overburden of soil, flint, and cotton rock, aggregating 6 to 10 feet in depth. When a working floor has been thus established, track channelers are installed, which make parallel cuts from 20 to 30 feet long and 10 feet apart. Cross channels are then run and the key-blocks removed. These blocks are broken away from the quarry bed by wedges driven into the channel cut, assisted by the derrick.

The channelers commonly employed are of the Sullivan single-gang direct-acting type, class "Y," although a few of the double-gang indirect-acting machines are still used for roughing work.

The Sullivan channelers carry their own boilers, thus securing a constant supply of dry steam at 130 to 140 pounds pressure. The bit used, up to a depth of six feet, is composed of three pieces, each 1¼ x 2¼ inches; the outside steels cutting at right angles to the channel, and the center at an angle of 45 degrees. This arrangement permits the cut to be started with a gauge of from 2½ to 3½ inches, which is necessary on account of the depth of the cuts. Below six feet, the ordinary five-piece gang is used. These channelers cut two ledges at one lift, the depth ranging from six to 14 feet (see the photograph above), resulting in increased efficiency in production.

The valve motion employed in these machines allows absolute and instantaneous control of the steam distribution, so as to give a heavy blow or a light tap as required. Carthage stone does not ordinarily show stunned or shattered edges under the channeler blow, but this difficulty sometimes occurs, and many cubic feet of valuable stone have been saved to the producer through the action of this valve. The former practice of considering the quarry bottomed upon the appearance of flint, due to the inability of earlier styles of channelers to cut this rock, was eliminated with the introduction of the hard-hitting Sullivan machines some seven years ago.

A typical cutting-shed in the Carthage District.

A further advantage of this valve motion consists in a cushion valve, which chokes the exhaust instantly in case the steels fail to strike solid rock,—e. g., in encountering a mud seam. This prevents damage to the front cylinder head.

The Sullivan Channelers have cut as high as 225 square feet in a day of 10 hours, but the average rate, month in and month out, is from 125 to 150 square feet per 12-hour shift. Several new improved Sullivan machines have recently been added to the district equipment, which are surpassing the records of the earlier "Y" Channelers for cutting speed and durability. In a year's time one machine has cost but $20.00 for repairs.

MILL WORK.

The mill blocks are removed from the quarry by means of plug and feather holes, drilled by air hammer drills. The Sullivan "Class D-15" Drill is largely used for this purpose, being operated by small air compressors. Previously, these holes were drilled by hand; the use of the "plug" drills has shown a wonderful saving over this old method. No blasting is employed. The blocks are carried to the mill by derricks and gravity trams. The mills contain from five to nine gangs of saws; a double gang taking a block measuring ten by nine by six feet. The stone is sawed both with and across the grain, and its hardness is indicated by the rate of sawing, which rarely exceeds two inches per hour. The saws are driven by a line shaft, operated by straight-line or Corliss engines.

LABOR.

The quarries employ from 250 to 300 men, who live in and near Carthage, the workings being within a mile or two of the business center. Stone cutters receive $4.50 per 12-hour day, machinemen 25 cents per hour, hoister and derrick engineers $2.00, and quarrymen $1.75 per day. Shipping facilities are excellent, since Carthage is on the Missouri Pacific, Iron Mountain, and Frisco lines.

OPERATORS.

The following quarry companies produce the greater part of the limestone quarried in the Carthage field:

CARTHAGE SUPERIOR LIMESTONE Co., R. M. Richter, President and General Manager; G. S. Beimdick, Treasurer; C. H. Carter, Superintendent.

Carthage Stone Co., Curtis Wright, President; J. W. Ground, Vice-President; W. R. Logan, Secretary and Treasurer; W. W. Wright, Assistant Secretary; James Logan, General Manager.

Carthage Quarry Co., Eugene O'Keefe, President; F. W. Steadley, Vice-President; J. E. O'Keefe, Secretary and Treasurer; Martin A. McNerney, General Manager.

Spring River Stone Co., H. C. Johns, owner and manager.

Carthage Building Stone Co., A. H. Caffee, President; Geo. Allen, Vice-President; Millard Bryan, Secretary, Treasurer, and Superintendent; J. P. Newell, General Manager.

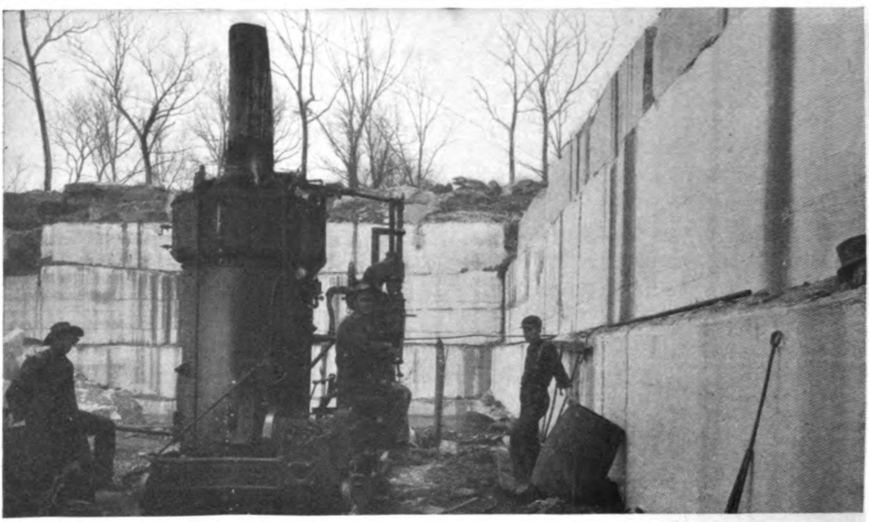
Carthage Marble and White Lime Co., Geo. T. Riddle, President; Fred J. Remmers, Secretary; Henry Hatsfield, of St. Louis, General Agent; R. W. Jay, Superintendent of quarries.

Missouri Stone and Construction Co., N. F. Wright, President and Manager; E. Powers, Vice-President; J. E. Hall, Secretary.

Myers Stone Co., W. B. Myers, President; Frank M. Myers, Vice-President and Manager.

The demand for Carthage limestone is constantly increasing, and the quarries are kept at their full capacity to supply the market. An innovation of recent date is the introduction of natural gas as a fuel, in some of the quarries.

At Phenix, Missouri, in Greene County, northeast of Carthage, the same grade of white limestone is quarried by similar methods to those employed in the Carthage district. Sullivan "Y" Channelers are largely used. The chief operators in this locality are the Phenix Stone and Lime Co., Messrs. C. R. Hunt, President and General Manager, W. C. Scarritt, Vice-President, and E. H. Jones, Secretary; and the Missouri Crystal Stone Co., Messrs. J. W. Lyman, President, J. H. Blair, Vice-President, H. A. Sutermeister, Secretary and Treasurer, and W. Delarue, Manager of the quarries. Both of these concerns have general offices in Kansas City, Mo. A description of the Phenix quarries will be published in a later number of Mine and Quarry.



A Sullivan Channeler in a well-developed quarry. Note the whiteness of the stone.

ADAPTABILITY OF HAMMER DRILLS.

[EDITOR'S NOTE.—The special uses to which air hammer drills of various sizes may be put in quarrying, mining, and construction work seem to be limited only by the ingenuity of the user, of which the following is an example. In the February, 1907, issue of this magazine will be found another instance of this adaptability, under the caption "Channeling Granite with Hammer Drills."

CLAREMONT, N. H., Sept. 12, 1907.
MINE AND QUARRY.

We have recently completed here a bit of engineering, which, while in itself of minor importance, exemplifies in an interesting way the range of adaptability of the hammer drill. In installing the pipe line for the water system of one of our new buildings, it was necessary to run a 10-inch pipe horizontally through a river retaining wall five feet thick. This hole had to be 28 inches in diameter to allow the flange to enter with the necessary clearance. It was necessary to build a cofferdam to lay bare the wall at the required point. The work had, therefore, to be done as rapidly as possible.

A Sullivan air hammer drill of the type used for stoping, with pneumatic cylinder feed and hollow steel, was mounted for this purpose, as shown in Figure 1. A template was then made as per Figure 2, to start the holes and guide the drill. The end "A" consisted of two-inch lumber mounted close to the wall, and containing a circle of 28 inch-and-a-half holes, at equal distances, giving a space between each hole of or a little over three-eighths of an inch. The end "B" contained an equal number of shallow holes in line with the holes in "A," for the reception of the feed-piston point. The drilling was accomplished in the usual manner, water being forced into the mouth of the holes instead of depending on the exhaust air for the removal of the chippings. By this means holes to a depth of four feet and over were readily drilled. The remainder of the core was taken out from the other side of the wall with a Sullivan hand-operated hammer drill, used for drilling plug holes. When the holes were finished, the partitions were broached out by a mining drill with pneumatic feed and two light shots of powder removed the core. The actual time required for drilling was 13 hours. The drilling was begun without the water jet, and a material increase in the rate of speed was observed after the water was introduced. There was also an appreciable gain in the length of time the steel would run without resharpening.

Yours truly,
GEO. H. GILMAN.

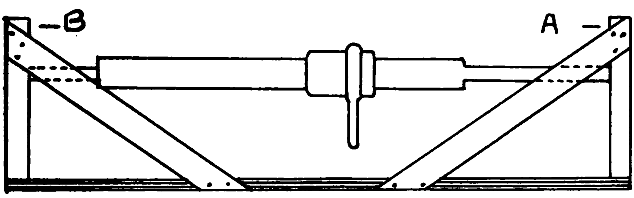


Fig. 1.

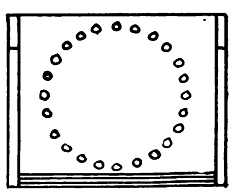


Fig. 2.

Template and Frame for boring through a wall.

Panorama of Ojuela, showing miners' houses, one of the shafts, and par

DIAMOND DRILLING AT MAPIMI.

WRITTEN FOR "MINE AND QUARRY"

By J. F. Bennett.*

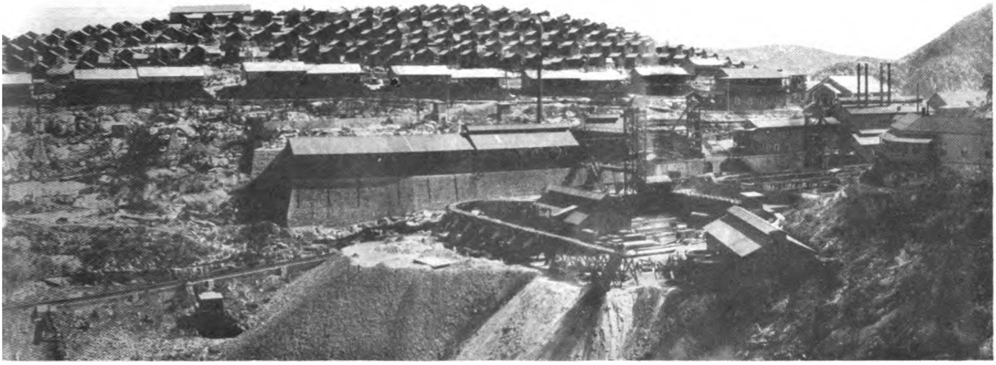
Mining men naturally think of the Lake Superior iron and copper district as the region of this country where diamond-core drills have been most generally employed for mine exploration and prospecting. Some of the Mexican fields, however, can also furnish examples of consistent, long-continued, and profitable drilling.

Chief among these examples is the work done by the Compania Minera de Peñoles, at Mapimí, in Durango. Mapimí is about 24 kilometers southwest of Bermejillo, with which it is connected by a 30-inch gauge road, owned and operated by the company. It is at the northwestern extremity of the Sierra de la Bufa de Mapimí. Here the precious metals have long been sought, even in the days of Spanish conquest; and the old stopes and workings, the piles of dirt and slag, which mark the site of ancient *haciendas*, remind one of those early times, when quicklime was used for blasting, when the ore was "hoisted" in rawhide *surones* on the backs of *peones*, and packed on burros to the quaint adobe smelters nestling in the valley, under the shadow of the towering peaks, to be treated a few hundred pounds at a time.

But now the visitor finds instead only the locomotive with its shrill whistle, the towering stacks, the great furnaces, and the familiar scenes of a modern metallurgical plant.

The company's general offices, power plant, and reduction works are at Mapimí, but its mines are at Ojuela, 10 kilometers away in the hills. The formation encountered is one which makes diamond drilling an economic necessity. The ore, a silver-lead, occurring as sulphide, oxide and carbonate, is deposited irregularly in pockets of varying dimensions, usually connected by pipes or stringers through the country rock of limestone. The mine is opened by levels from the shaft, and on each level drifts are run at right angles, about 120 meters apart. The territory covered by the mine is thus divided by

* El Paso, Texas.



of the rack road. The smelter, at Mapimi, is far to the left, in the valley.

the levels and drifts into cubes. These cubes are carefully probed by diamond-drill holes, run from the drifts, in all directions, to determine the location of the pockets, their size and frequency, and the best points from which to reach them. By this method it is impossible to miss any body of ore of appreciable extent, and at the same time, if ore is not discovered, the expense of drifting is avoided.

The company at present employs 17 diamond drills, and performs about 12,000 feet of core drilling per month. The drill-holes are run at right angles to the drifts, about five meters apart, to an average depth of about 60 meters. Horizontal holes predominate, but there is also considerable angle work.

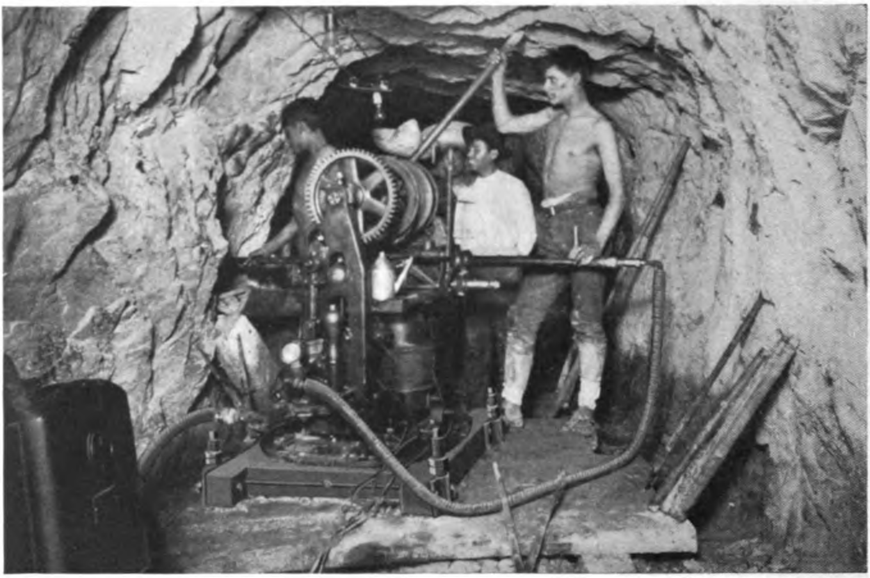
Four of the machines are of the Sullivan "R" type, which have a capacity of 300 feet in depth and remove a 15/16-inch core. These drills are fitted with improved screw feed with friction escapement, and are operated by electric motors on a 250-volt direct current, which is stepped down from the 6,600-volt alternating current transmitted from the power plant at Mapimí. The remaining drills are of an early Swedish type. They are run by small electric motors, but the diamond bit is advanced by hand.

The average cost of drilling for the year 1906 for all the drills was about $2.10 (Mex.) per meter. Two Mexicans are employed on each drill, a runner at $2.00 (Mex.) and a helper at $1.25 (Mex.) They average about five meters per 10-hour shift with the Swedish drills and seven meters with the Sullivan "R" machines. The cost of labor only, for the Swedish drills is thus 65 cents (Mex.) per meter, and 46.4 cents for the Sullivan drills.

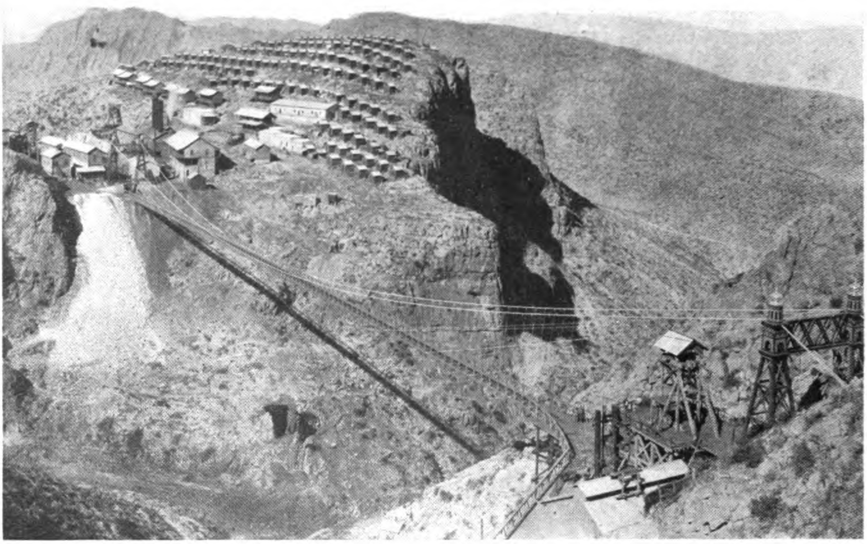
Owing to the soft, even character of the rock, it is possible to use small carbon, weighing about one karat, of a grade costing $40 gold per karat. The table on page 187 shows the average cost of the company's drilling work for the first five months of 1907. All values are figured in Mexican currency.

The photograph on the following page shows one of the Sullivan drills in operation.

The Compania Minera de Peñoles is one of the most substantial concerns of the kind in the Republic, and one of the most modern in its methods and equipment, aside from the fact that it has



A Sullivan "R" Electric Diamond Drill in the mines of the Compania Minera de Peñoles, Ojuela, Durango. Mexico.



Ojuela from one of the several shafts. The ore is carried to the cog-road across the suspension bridge.

used diamond drills so intelligently and to such good advantage for the past 10 or 12 years. Electric power, generated at Mapimí, is employed to operate air compressors, hoists, pumps and to light the mines. Air drills, size 2 1/4-inch, including about a dozen Sullivan "US" machines, are employed for development work. A suspension bridge connects one of the principal shafts with the ore bins at the terminus of the railroad which connects Ojuela with Mapimí. This line includes a rack road three kilometers long, with a grade of from 10 to 14 per cent., running from Ojuela to the foot of the mountain. The panoramic photograph reproduced on page 184 shows the mines and miners' houses at the right and the rack road in the center. The reduction works are in the plain at the left, not visible in the picture.

The reduction plant includes five 46 x 162-inch lead stacks; roasters and Huntington converters, and a 200-ton concentrating plant. It is capable of treating about 1,000 tons of ore per day. The writer acknowledges with thanks information furnished for this article by Messrs. Kuno B. Heberlein, General Manager; A. Frey, Superintendent of diamond drilling; and O. R. Whittaker, Mine Manager.

Month	Labor Cost, including Salaries of Foreman, Setter, etc. Per Meter	Diamonds, Cost per Meter. Diamonds at $40 Gold per Karat	Total Cost, including Power, etc. Per Meter	Average Drilled per Month, per Machine, Meters
Jan.	1.01	.09	1.74	290
Feb.	.91	.24	1.76	266
Mar.	1.00	.08	1.71	250
Apr.	.93	.22	1.66	286
May	1.19	.15	1.93	270
Average for 5 Months	1.01	.156	1.76	272.4

THE NEW YORK, NEW HAVEN & HARTFORD RAILROAD TUNNELS, AT PROVIDENCE, R. I., AND TERRYVILLE, CONN.

By H. N. Harding.*

The New York, New Haven & Hartford Railroad, in its work of bettering the facilities for handling traffic, etc., is spending a large amount of money each year in abolishing grade crossings, double-tracking its system, and reducing grades by tunneling.

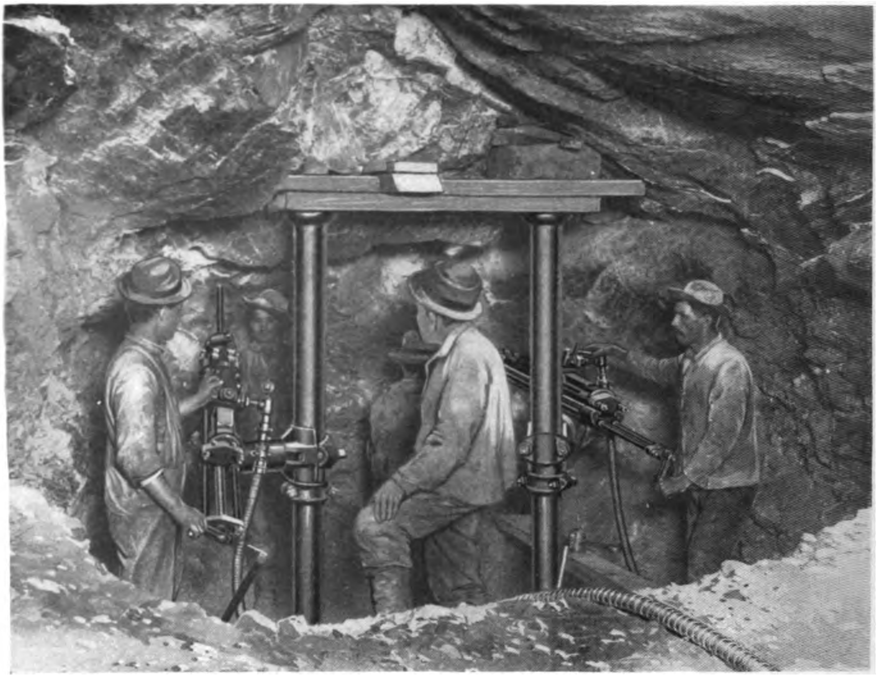
Two of these tunnels are now under construction, one at Providence, R. I., and the other at Terryville, Conn., and it is understood that several others will be started within the next year or two.

THE PROVIDENCE TUNNEL.

The object of the tunnel at Providence, which is known as the East Side Tunnel, is to furnish better service between Providence and Fall River, and to eliminate several grade crossings.

The construction of the tunnel will shorten the distance between Providence and Boston four miles, and will very materially decrease the running time between the two cities, on account of the

* 43 Islington St., Portsmouth, N. H.



Sullivan Tappet Valve Drills in the heading of the Providence Tunnel.

grade crossings at Pawtucket. It will also bring the Fall River trains into the heart of the city, whereas they now leave passengers fifteen minutes' ride by electric cars from the business section.

The need of better facilities for handling passenger traffic at this point has long been felt, and it was estimated at first that from 125 to 150 trains per day would pass through the tunnel (which is considered about two-thirds or three-quarters of its capacity), with a steady increase until the limit was reached, when it was proposed to build another tunnel of the same size alongside of the one now under construction. On account, however, of the rapidly growing demand for better service, it has now been decided to start work on the second tunnel immediately after the first one is completed.

The tunnel will be about 5,000 feet long by 30 feet wide by 24 feet 5 inches high, cut through rock and lined with concrete. It will accommodate two tracks and will be equipped with trolley wires, as the trains to Fall River are now run by electricity. The through passenger trains will also be hauled through by electric motors, thereby doing away with the smoke difficulties.

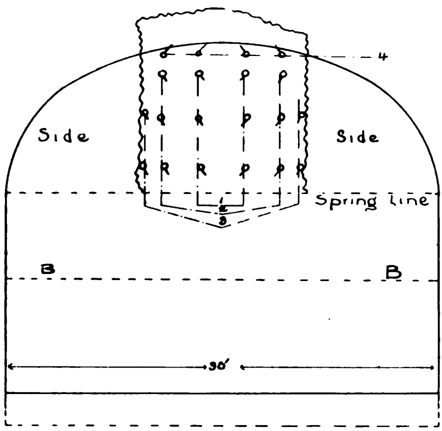
The contract for the construction was let in July 1906, to Messrs. McCabe and Bihler of Seattle and Tacoma, Washington, who have had extensive experience in tunnel building in the West, and work was begun in August of the same year. A great deal of preliminary work, such as moving buildings, earth excavation, and the construction of concrete abutments, was necessary before work on the tunnel proper could be started, which, together with the limited space in which to place material for the fill later, made work necessarily very slow; from four

to six months were occupied by this class of work. The work on the tunnel proper was started about January, 1907, and is being carried on from each end, one end being several hundred feet in advance of the other, on account of the preliminary earth excavation there necessary.

The rock encountered is in general of a soft slaty formation, although fairly hard in some places. For the most part, however, it resembles slate and even coal, and for this reason a great deal of timbering is necessary.

The work is accomplished as shown in the accompanying sketch, by first driving a 12 x 14-foot heading at the top of the tunnel, high enough to include the concrete lining. The method of drilling and shooting the heading is also shown in the sketch. The holes are drilled six to eight feet deep and are shot in the following order: First the center set of six holes, and then in order the next outer row of six and a set of four rib holes, leaving the top row to be fired last. In loading the top holes a very light charge of powder is used, so that when this last round is fired no more of the roof than is necessary is brought down. In drilling this heading two 3¼-inch UF-11 Sullivan Tappet Valve Drills are used. Each drill works two shifts of 10 hours each per day and drills about 150 feet of holes during this time. These machines were adopted after a series of tests by the contractors with drills of several makes. They have been in use since the work was started, some ten or twelve months ago, and have demonstrated excellent efficiency and durability, the cost of repairs being exceedingly low.

After the heading is shot the side walls are taken out to the spring line. In removing the rock next to the heading, a drill is mounted on a column and set up at right angles to the heading; as the work approaches the outside of the cut, a tripod is used and the drill set parallel to the heading. After the rock has been



East Side Tunnel Heading, showing method of placing holes.

removed the forms for holding the concrete are set in place and a roof of concrete two feet thick at the top and four feet at the spring line is laid, resting on the rock foundation at the spring line. The space between the top of the concrete roof and the rock arch is filled in with grout.

In drilling and removing the bench which extends from the spring line to the tunnel sub-grade it is first necessary to put in short holes about six feet deep, lowering the level to the line B, in order that the steels used in drilling to the subgrade may be removed without striking the roof. The latter holes are from 12 to 14 feet deep, placed about eight feet back from the face of the bench and inclined slightly from the center of the tunnel either way, so that a shelf of rock will be left for the concrete roof to rest upon until the side walls are put in place.

The muck from the heading and side cuts is carried back to the bench in cars, where, together with the muck from the bench, it is transferred by a Model 20 Marion Steam Shovel, operated by compressed air and especially adapted for tunnel construction, to other cars, drawn by an electric motor, which carry it to scows running down the river to the dump.

Open cut and portal of East Side Tunnel, showing Steam Shovel at work and method of placing roof and lining.

The concrete for the heading is mixed at the entrance and carried to the inside of the tunnel by means of an overhead rail, which carries the car over the steam shovel without in any way interfering with the work of removal of the bench.

The concrete for the side walls is placed by means of a large form, about 100 feet long, which moves along on a track placed on the floor of the tunnel, about two feet from each wall. This form carries a concrete mixer, driven by a motor, so that the concrete may be discharged directly into the wall, until the form is full on either side, when the form, concrete mixer and all, is removed ahead its own length and the next section put in place.

Work on the tunnel is now progressing rapidly, the heading going forward from nine to 12 feet per day of 20 hours (two shifts of 10 hours each) on each end of the tunnel, while eight lineal feet of concrete arch to the spring line is put in place during the same time at each end. A total of nearly 4,300 feet of heading has been driven, while the work of widening and taking out the bench is following on very closely. It is expected that the headings will meet about April 1, 1908, and that the tunnel will be ready for traffic in September, 1908.

The power plant at each end is equipped with a 900-foot steam-driven air compressor which furnishes power for the concrete mixer, steam shovel, and rock drills.

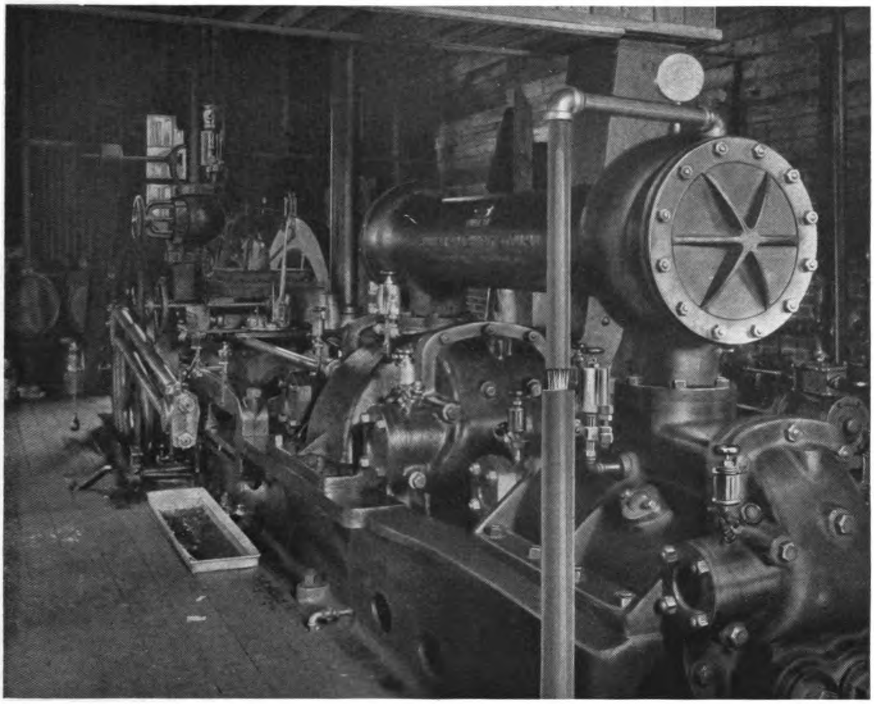
THE TERRYVILLE, CONNECTICUT, TUNNEL.

As mentioned above, the New York, New Haven & Hartford Road is also making extensive improvements to its line between Bristol and Waterbury, Connecticut, which includes a tunnel near Terryville; the principal object being to do away with the heavy grades which are now encountered, and at the same time reduce the mileage about two miles in 14. Messrs. McCabe & Bihler have a contract here also, being in charge of two sections. Their work covers between five and six miles, including cut and fill work as well as the tunnel through Sylvan hill, which will be about 4,000 feet long.

The work on the cut and fill has been pushed rapidly, and while the work on the latter is particularly heavy, being in some places a matter of 75 feet or more, this is nearly 50 per cent. completed.

Work on the tunnel is carried on in much the same manner as at Providence, but as the improvements at Terryville are not deemed as important as at Prov-

Sullivan Drill on tripod in the Providence Tunnel, drilling the side holes.



Sullivan Two-Stage Air Compressor at the Terryville Tunnel.

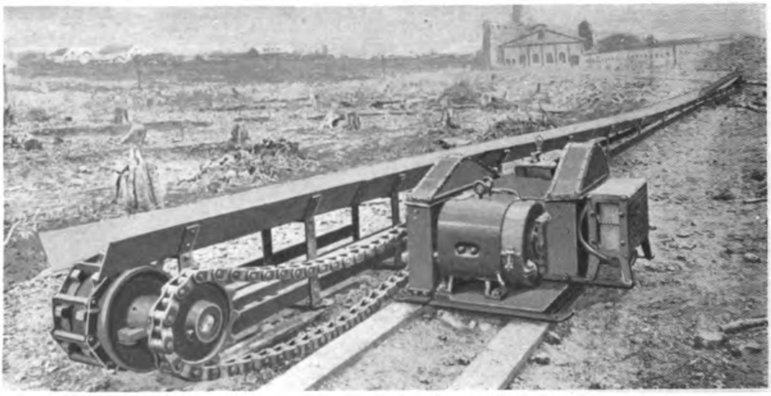
idence, the work is not being pushed as rapidly, and it will probably be the middle of the summer of 1909 before the same is completed. It is planned in the case of the Terryville tunnel to carry the work of the heading, side cuts, and bench along practically together. This tunnel is being worked from one end only, so that the muck may be used in a fill on this end.

The rock encountered here is a granite, as hard as flint in some places. The heading is 12 by 14 feet and the work is done in two shifts, one doing the drilling and shooting and the other the mucking. The average advance per day in the heading is six to eight feet; the best run thus far for two weeks being 78 feet.

The equipment used at this place consists of a straight-line, steam-driven, two-stage air compressor of the Sullivan "Class WB-2" type, capacity 1,100 cubic feet of free air per minute, with a complete outfit of Sullivan UF-2 differential valve drills, which are particularly well adapted to the hard rock.

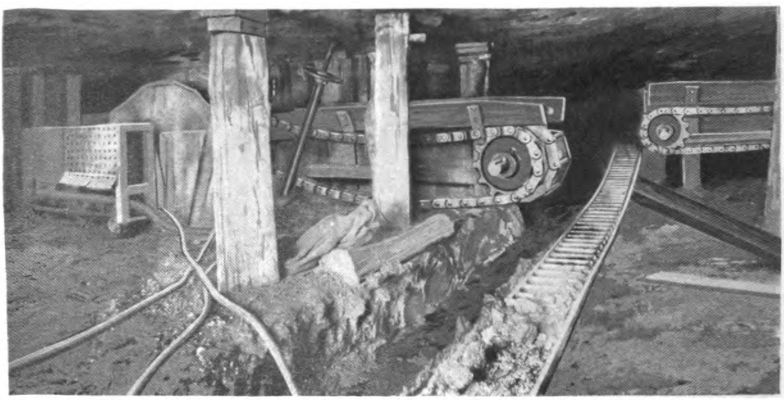
As compared with the West, it is claimed that the East has very little single-track mileage, but it is nevertheless true that there is more double-tracking now under way in New England than has been the case for many years. This not only applies to the N. Y. N. H. & H. R. R., but to the Boston & Albany and Boston & Maine.

The writer is indebted for information contained in this article to Mr. P. R. Haley and Mr. John Haley, superintendents for Messrs. McCabe & Bihler at Providence, R. I., and Terryville, Connecticut, respectively.



Long-Wall Coal Conveyor.

Face and Heading Conveyors.



Triple Conveyor System. Face Conveyors to right and left, Heading Conveyor in center.

MECHANICAL CONVEYORS AS APPLIED TO LONG-WALL MINING.

By J. I. Thomas.

[The Vinton Colliery Company, Mr. C. L. Hower, Superintendent, is operating extensively on the long-wall system at Vintondale, Cambria Co., Penn. With the kind permission of Mr. J. I. Thomas, Assistant Superintendent of this company, the paper written by him on the subject "Mechanical Conveyors as applied to Long-Wall Mining," and read before the Coal Mining Institute of America at the summer meeting, June 11-12, 1907, is reprinted below. Acknowledgments are also due Mr. Thomas for the sketches of the plan of working, and some of the photographs shown.—Editor.]

"Transporting coal from the working face to main haulage roads by means of mechanical conveyors is a comparatively recent departure from ordinary mining methods. This system, which was first introduced in England, was early recognized by leading operators as possessing superior advantages over the usual manner of working, especially in thin coal seams. Owing to the fact that long-wall mining in this country is not carried on to a large extent, the conveyor system has received but little attention among operators; consequently there are but a few installations, the largest of which is probably in the mines of the Vinton Colliery Company, at Vintondale, Penna.

"Remarks in this paper will be confined to the practice observed and results obtained by this company while mining with this method.

"The coal worked in this territory is the 'B,' or Lower Kittanning seam, 42 inches in thickness, which lays on a pitch of 8 per cent, with an average of 200 feet of cover. The coal is of a soft and friable nature, free from slate bands and bony coal, but interspersed with sulphur pyrites, which at times cause considerable annoyance in cutting and drilling. The bottom is a mixture of coal and fire-clay, while the roof is composed of from 8 to 12 feet of black slate, overlaid with sandstone. The slips in the slate are well marked, and lay at an angle of 25 degrees with the line of the greatest dip.

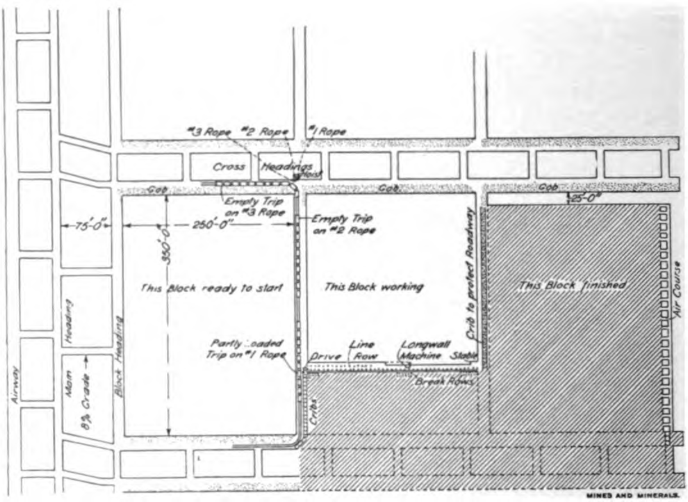
"The block work, which is a modification of long-wall mining, was first started in the No. 3 mine of this company 7 years ago. At the outset cars were run around the working face and loaded. This method brought only fair results, owing to the necessity of using small cars, steep grades, and difficulty in keeping roadways open. Arrangements were then made for the placing of a conveyor along the face, allowing the cars to be run under the head-end to be loaded.

"The first conveyor, which was made entirely of wood, was a cumbersome affair and much time was consumed in moving it laterally along the face after the cut had been loaded out; but after a year's trial the results obtained were so gratifying that metal conveyors were designed and ordered, and preparations were made to employ this system on a much larger scale.

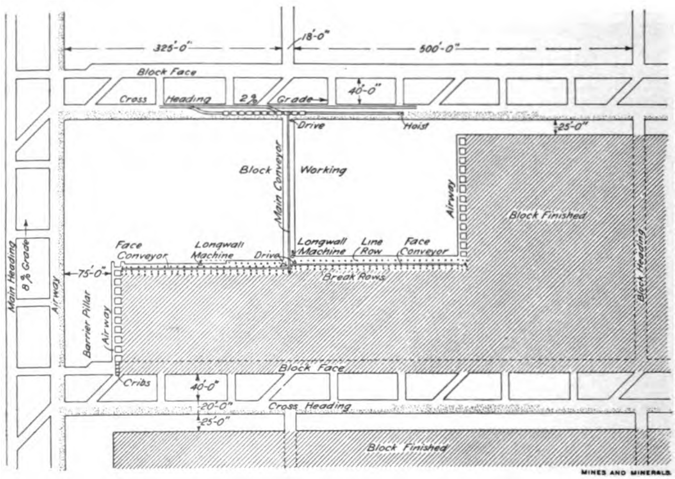
"The conveyor system is very flexible, and numerous methods of working are applicable, as the condition of the territory demands.

"In Vintondale, at present, there are two different arrangements—i. e., the single-conveyor method, which has been mentioned, and the triple-conveyor system, by which two face conveyors dump alternately into a third conveyor, which in turn dumps into the mine cars. Both air and electricity are used as the driving power.

"In the No. 3 mine, where the single-conveyor system is being used, with compressed air as power, the main heading and air course are driven up the pitch through the center of the property. Cross-headings are driven off the main at intervals of 400 feet and run to the outcrop.



Plan of workings, Single Long-Wall Conveyor System.



Plan of workings, Triple Long-Wall Conveyor System.

These headings are 20 feet wide, with an 8-foot roadway carried next to the pillar, which is 40 feet thick. Barrier pillars of 75-foot thickness are maintained on each side of the main entries. Block headings are driven perpendicularly off the cross-entries at 265 feet centers. This allows a solid face of 250 feet. These block headings are driven 15 feet wide, but bottom is lifted only 7 feet wide near the rib, and of such depth to allow a clearance of 6 feet from the top of rail. The remaining width acts as a shelf for the support of the drive and long-wall machine. As the block headings are driven for a distance of 350 feet into the solid coal, it is found necessary to carry along a good line of bratticing for the purpose of ventilation.

"The block nearest the outcrop is first attacked. On this block it is necessary to maintain an air-way at the rear end. This is done by driving along with the block a place 4 feet wide, leaving a pillar 10 feet thick between it and the edge of the block. The coal is extracted to within 25 feet of the upper heading, when the conveyor is removed to the next block, which is worked out in the same manner; and so on until the coal in the whole tier of blocks is recovered. In the meantime, the pillar left by the block and the chain pillars are being mined by hand. The time consumed in removing equipment from one block to another is usually about 15 hours.

"The type of conveyor consists of a trough or pan made of sheet steel ⅛ inch thick, 12 inches wide at the bottom, 18 inches wide at the top, and 6 inches high, set on strap-iron standards. The conveyor, which is 250 feet in length, is made up in sections of 6, 12, 15, and 18-foot lengths, connected together by means of ½-inch flat-headed bolts, countersunk. The front is inclined for a distance of 45 feet, to allow clearance for mine cars to pass under. The rear end is inclined for 15 feet to compensate for the size of sprocket wheel. A return runway for the chain is afforded below the pans by angle irons.

"A cast-iron driving sprocket, 18 inches in diameter and 13-inch face, is attached to the front end. On the shaft of this sprocket, which is extended 12 inches beyond one of the bearings, is keyed a 12-tooth, 16-inch diameter sprocket, which connects with the driving mechanism. The rear-end section consists of a frame work made up of two I-beams, six feet long and strongly braced, on which rest the take-up boxes for keeping the chain in adjustment and the rear sprocket-wheel over which the chain returns.

"The conveyor chain is made of either steel or malleable cast iron, held together by bolts, the ends of which may be riveted or fitted with nuts. As it is impractical to secure a chain that will not break, they are designed so that repair can be made expeditiously.

"The power is carried to the different machines by means of a 2-inch pipe, which is run from the main supply along the lower heading to the top of the block heading. A connection is here made with the hoisting engine. The line is carried on props down the block heading to the conveyor, where it is connected by means of a 2½-inch wire-wound rubber hose to a 2-inch pipe that runs the entire length of the block and attached to the conveyor. This pipe has outlets with 2-inch stop-cocks at intervals of 50 feet, to which the hose of the mining machines and air drills may be attached. This arrangement necessitates carrying only a short length of hose on these machines instead of one reaching the whole length of the block.

"From the end of the conveyor a 1¼-inch pipe is run to the air engine. In this pipe is a valve, which is connected to a rod that reaches to the head end of the conveyor. It is from this point that the conveyor is controlled when running. As the air line needs to be shortened five feet nearly every day, several sections of different lengths are kept near at hand, so that this change can be quickly made.

"The cars are handled to the conveyor by means of a double cylinder, with an 8x10-inch double friction-drum hoisting engine. The drums work loose on the shaft independent of each other, and are equipped with a powerful differential brake that will hold any load the engine will hoist; 500 feet of $\frac{5}{8}$-inch rope is reeled on each drum. A small hand drum, on which is reeled 150 feet of $\frac{1}{2}$-inch rope, is used to lower the cars around the curve.

"The cars are dropped into the lower heading from the main haulage, and pulled, either with mules or a small engine, to the top of the block heading. Here the rope of the small drum is attached to the coupling between the first and second car, and the cars pushed around the curve. One of the ropes of the hoist is now attached to the rear end of the trip, which is usually ten cars, and the small rope is freed. The trip is then dropped to the conveyor to be loaded. Another trip is attached to the other rope of the hoist in the same manner. This trip is held on the block entry until the first trip is loaded. This having been accomplished, the loaded trip is dropped to the bottom of the block heading and the rope disengaged. The driver here takes the cars and hauls them to the main haulage. The rope is then pulled to the top of the block heading and attached to the cars, as described. In the meantime, the empty trip on the block heading has been dropped to the conveyor and started to be loaded. This change usually occupies two to three minutes. Electric signal-wires are run the length of block headings, by which the head man signals the engine boy.

"The drive, which is a small double-cylinder engine with reduced gearing, is mounted on a frame and attached to the conveyor. The power is transmitted by means of a steel thimble roller chain to the sprocket on the drive shaft of the conveyor.

"The drill used for boring the holes is an ingenious tool; the weight of auger and drill does not exceed 20 pounds. The machine is a small four-cylindered air-engine, and has a gear on the crank-shaft that meshes with a gear on the shank of the machine. The auger is attached to a small chuck that is screwed on to the end of the shank. A hose, $\frac{3}{8}$ inch in diameter and 50 feet long, attached to the conveyor pipe, furnishes the power for the drill.

"The complement of men required to run a block is 13—i. e., block boss, machine runner and helper, driller, who also acts as shot-firer, engine boy, head man, and six loaders.

"The 'block boss,' or leader of the crew, has direct charge of the block. He must be a man who has some knowledge of mining and the care of machinery, and possess good executive ability. The balance of the crew, with the possible exception of machine men, are generally non-English-speaking men.

"In preparation for the day's work, the machine has cut one rail (30 feet) on the previous afternoon. In the morning this coal is shot down and the loaders begin work immediately. It requires from $4\frac{1}{2}$ to 5 hours for the machine men to finish the cut. The machine is then overhauled and moved up in position to start the return cut. After finishing their own work, the runner and his helper go back on the block and make preparations for the moving of the conveyor. This consists of setting a line of props, called the line row, about 8 feet apart, and a distance from the conveyor equal to the depth of the undercut. As these are placed the old line row, which is now against the conveyor, is withdrawn. The pulling jacks for moving the conveyor are distributed along the block 40 feet apart and placed in position

"The shot-firer keeps closely after the machine, and is through shooting shortly after the undercut is finished. He then starts from the far end of the block to drill holes in the new face. It usually takes him about two hours to drill the entire width of the block.

"Each loader is supplied with a pick and shovel and a piece of sheet iron 9 inches wide and 6 feet long, which he attaches to the conveyor to act as a side board. As each loader cleans up his place he moves forward to the head of the line. This continues until the coal is loaded out, which usually requires about 6½ hours.

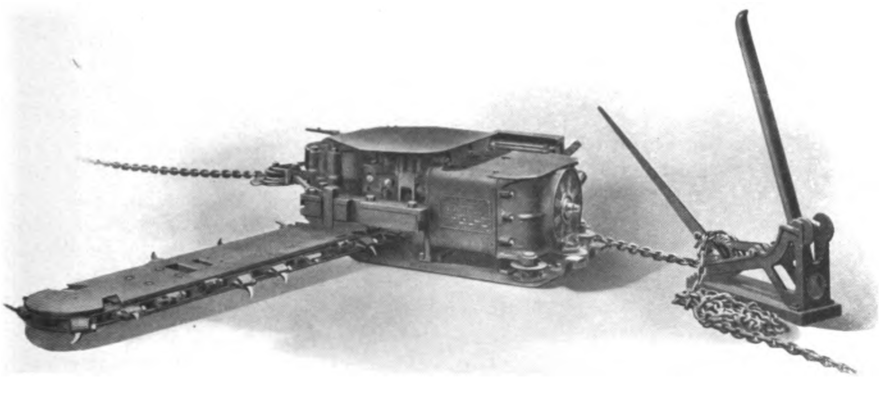
"When cleaned up the drive is reversed and the timber, which has arrived on the last trip, is run through on the conveyor to such points on the block where it is required. When this is accomplished the power is shut off by means of a valve located at the top of the block heading. The hose is disconnected from the main feed-pipe and the conveyor is moved up to the line row. This lateral move of the conveyor requires very little time, very seldom exceeding five minutes. A break row, consisting of two rows of props set two feet apart, is now placed along the lower side of the conveyor. These props are set on a cap piece, placed on a small pile of slack, and wedged at the top. Two break rows are all that is necessary to protect the block. In the meantime, a portion of the crew are engaged in pulling out the extra break row. This is the most hazardous work on the block, and is given personal attention by the block boss. Axes are used in this operation, and about 75 per cent of the props recovered are practically uninjured.

"While the block crew are employed timbering, the conveyor man and hoist-boy make the necessary pipe connections, and go along the conveyor with a pump-jack and level it up. They also build a crib at the head end, which is placed so as to prevent the roof from breaking over into the block heading.

"When the timber drawers have advanced such a distance from the machine that the noise of the exhaust will not annoy them, the machine begins cutting, and is usually able to have one rail, or about 30 feet, cut before the shift is over.

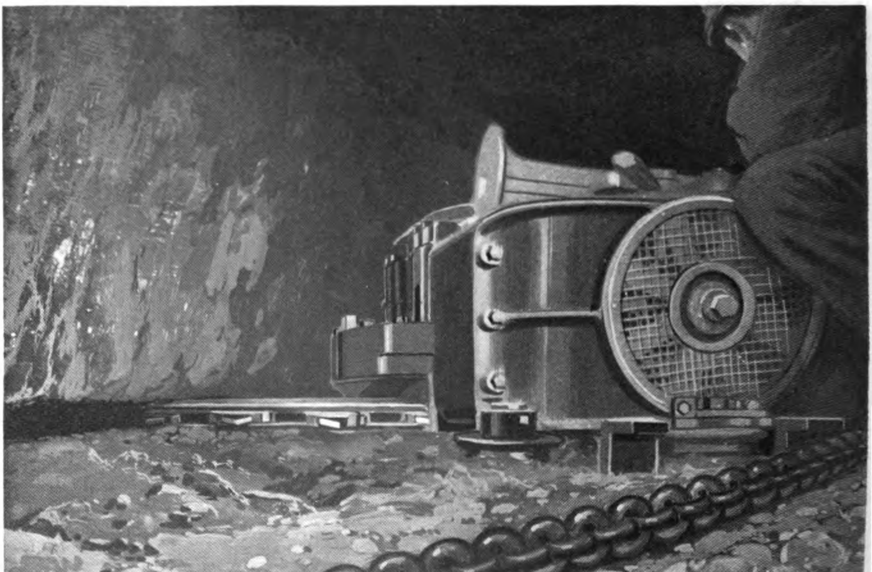
"With a 5-foot undercut the block throws 125 tons. Four cuts a week are, on an average, obtained from each block, which makes a daily average of 100 tons.

"Although the results obtained from this system of mining were highly satisfactory, it was found there was still room for improvement, especially with regard to the original cost of the development and the dead-work connected with the running of the block. It was with the



**Sullivan Electric Low-Vein, Long-Wall Coal Mining Machine.
Bar swung for cutting from left to right.**

Sullivan Electric Long-Wall Machine, class "CH-6," in the mines of the Vinton Colliery Co., Vintondale, Pa.; Machine in position to begin cut from left to right.



Sullivan Long-Wall Machine cutting from left to right. This view shows the machine swung out slightly from the face to avoid an obstruction in the coal.

idea of remedying these features, and of improving on other less important conditions, that the triple-conveyor system was designed and installed. After being in use for over a year in four of the mines, where electricity is the power used, the results obtained are even better than were anticipated.

"In laying out a mine for this system, the main entry and air-way are driven up or down the pitch, and cross-headings are driven off them at intervals of 400 feet at such an angle as will give a 2 per cent. grade; 75 feet barrier pillars are left on each side of the main entries. The cross-heading is driven 20 feet wide and gobbed on the lower side. The air course, which afterwards is used as the block face, is driven 20 feet wide, but no bottom is lifted: a 40-foot pillar is maintained. Block headings are run perpendicularly off the cross-headings at 518-foot centers; they are driven 18 feet wide, with bottom lifted in the center 5 feet wide, and to such a depth as will give a clearance of 5 feet.

"When the block is ready for operation, a conveyor 350 feet long is placed in the block heading, and along the face of the air course on each side is placed a conveyor 250 feet long, with delivery ends directly over the main conveyor, one being 5 feet in advance of the other. Each conveyor is driven by a 20-HP., 250-volt, series-wound motor, encased in a sheet-iron frame mounted on steel shoes, so as to be easily moved.

"Air-ways are maintained on the blocks by driving two places slightly in advance of the block face, 6 and 4 feet wide, respectively, with a 10-foot pillar between. The first place acts as a stable for the machine, and is driven by the machine. The air-way is pick-mined, and one man manages to keep these places going on the rear end of both blocks. By this arrangement no cribbing is necessary.

"The blocks are worked to within 25 feet of the cross-heading, when the conveyors are removed to another block. The remaining pillar is brought back along with the heading stumps.

"The power is carried to the top of the block heading by a 2-O wire. Here are attached two insulated twin cables, one to furnish power to the machines, the other for the drives and hoist.

"The cables are carried down the block heading, one on each side of the main conveyor, being attached to it by means of malleable-iron brackets. At the junction of the conveyors connections are made with the drives, also with a cable that is attached to each of the face conveyors.

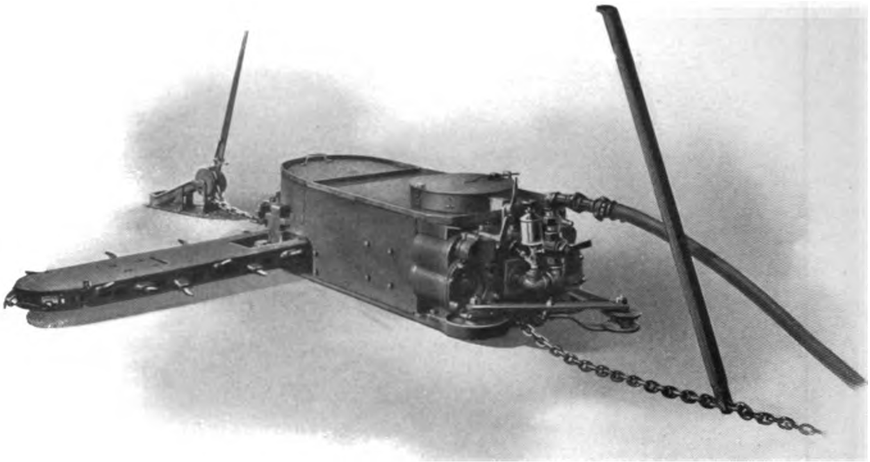
"Stations are established 50 feet apart on the face conveyor cables, to which connections are made with the short cable attached to the long-wall machines and electric drills. Switches are placed at the head end of the main conveyor, by which the power is controlled.

"The method of handling the cars to the conveyor is simple. A side track is laid 300 feet long, of which the block heading is the center. Connection is made with the main track at the lower end, and a cross-over switch is placed directly under the conveyor. At the upper end of the siding is placed an electric hoist. A trip of 14 cars is shoved into the empty track, and the rope is attached and the trip pulled up to the conveyor. Signal wires are hung between the conveyor and the hoist, and as each car is loaded the trip is pulled forward. When loaded, the trip is dropped on the loaded siding, the rope disengaged and attached to the empties.

"The crew operating a double block consists of 17 men—i. e., block boss, machine runner and helper, driller, shooter, two conveyor men, hoist boy, five loaders, and four timber men.

"Two long-wall machines are used, one for each side, although one machine can keep up the work in case of emergency.

"As the machine men finish cutting one block, they put the machine in position to start back on the cut and move over to



Sullivan Compressed Air Long-Wall Coal Mining Machine.

the next block and begin cutting. They are followed by the shooter and loaders. The driller sets the line row, and also has time to assist in loading.

"When a block is cleaned up, the timber men move up the conveyor, set the break rows, pull the timber, and make everything ready for the conveyor to start when the opposite block is loaded out.

"The main conveyor, which is made up of 12-foot sections, is disjointed about every third day, and one of the sections taken out and moved to the block heading next to be worked. The surplus length of cable is gathered on a reel located at the head end of the main conveyor.

"The working of the face is similar to that of the single block, with the exception that the machine men, loaders, etc., continue at their own special work during the whole shift, the dead-work being taken care of by the four timber men, thus not hindering the steady flow of coal, which averages 150 tons per day.

"For the purpose of keeping the machinery in as good a shape as possible, a skilled mechanic is attached to each mine. He assumes charge in case of an accident and makes necessary repairs, although most of the breakdowns are easily taken care of by the block boss and machine man.

"In the starting of a block is where the best results are obtained, as the roof requires little attention until about 100 feet have been extracted. It then begins to weigh heavy on the posts, and it is found necessary to carry three or four double break rows in anticipation of what is called the 'big break.' This usually occurs when the block is advanced from 100 to 150 feet, although in several instances a 500-foot face has been carried up 200 feet before the overhanging strata broke. After the sand rock is down, only two break rows are carried, and the roof keeps breaking behind the last row as the face is extended.

"The men are paid day wages, and as they become accustomed to the work and machinery are advanced accordingly. The block boss, as an incentive to secure the best results, is paid a small bonus per ton besides his regular day rate.

"The cost averages for the last two years show that block coal is loaded on the mine cars 35 per cent. cheaper than the district mining rate, but this cost can be materially reduced when a few improvements, now being worked out, are brought to a state of perfection. Among these may be mentioned a more simple mechanical rig for spotting the mine cars, and a scheme for reducing the amount of timber used."

LONG-WALL MACHINES.

(Note by W. R. Jarvis, Pittsburg.)

When electricity was decided upon as the most satisfactory motive power under the existing conditions, for both the conveyors and long-wall mining machines, thus necessitating the purchase of additional equipment, various types of undercutters were tried, with the result that the low-vein long-wall chain undercutter, designed and built by the Sullivan Machinery Co., of Chicago, Ill., was adopted, and there are several of these machines now in successful operation at Vintondale.

As these machines are only 5 feet 10 inches long when the cutter bar is in position for work, a reduction in the width of the block heading for the main conveyor was possible, as less space on each side is necessary to start the machine on its cut than was possible with other machines tried. It has been found unnecessary to drive this block heading more than 12 to 13 feet wide as compared with the previous requirement of 18 to 20 feet. The machine is only 36 inches wide, with the cutter bar under the coal, and only this distance is required between the face of the coal and the props or conveyor. The machines are built with bars 4 feet 6 inches and 5 feet 3 inches long.

The machine travels both ways across the face. It is fed by a chain stretched between two jacks. The accompanying illustration, page 197, shows the machine in the above position, with the two jacks. It will be noted that the machine rests on a sheet-steel plate, which forms the bottom of the frame, thus occupying the least possible space. No rollers or rails are required on which to run the machine while making this cut.

The machine is moved from place to place in the mine on a mule truck, although power trucks are sometimes furnished. The height of the machine when cutting is 21 inches, and on the truck the machine stands 29 inches above the rails. If desired, a truck is furnished having drop axles, which reduces the total height to 26 inches. The machine weighs 2,600 pounds, and the mule truck 800 pounds. The motor develops 30 HP. at 1,125 revolutions.

The cost of repairs is materially reduced by the friction clutch, which is connected with the feed mechanism and used on all machines of this type. The object of the friction clutch is to reduce the feed somewhat below that of the feed gears when harder than average cutting is encountered, and also in case of extremely hard cutting to limit the feed to an amount which will not cause undue strains on the machine or feed mechanism.

The machines at Vintondale are making a 250-foot cut, 5 feet deep, in from five to six hours, including all delays.

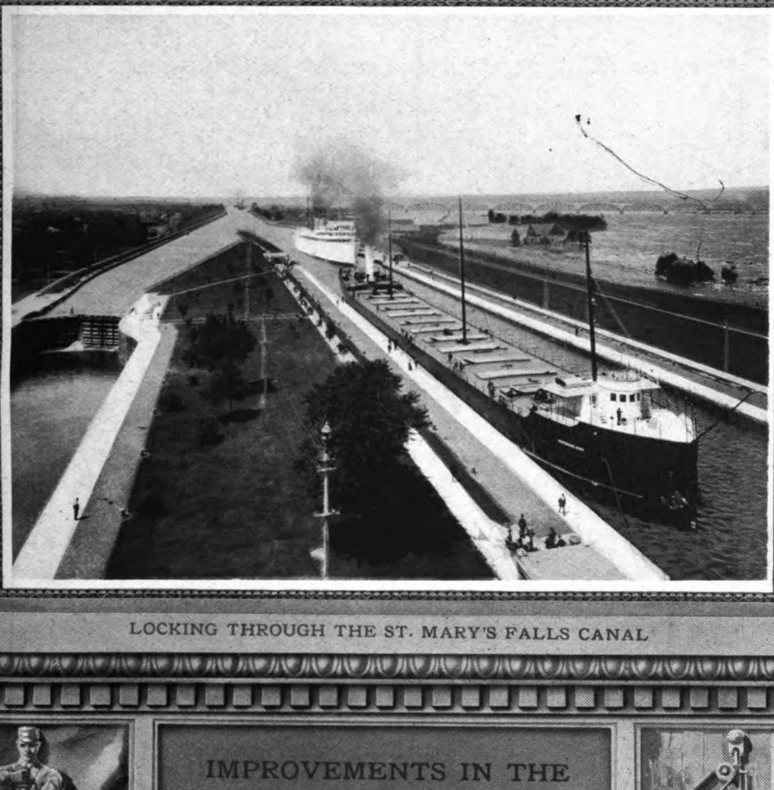
At the mines of the Gay Coal & Coke Co., Logan County, W. Va., a Sullivan machine, operating on the block system, has undercut a long-wall face 377 feet in length, to a depth of 6 feet 1 inch in 8½ hours, thus producing over 500 tons of coal.

Photographs of the machine in position for beginning the cut and while crossing the face are shown, as are also photographs of the undercutter itself and a similar machine designed for operation by compressed air.

The conveyors described by Mr. Thomas and used at Vintondale are manufactured under patents by the Central Mine Specialty Co., with offices at Vintondale, Pa.

MINE AND QUARRY

II. No. 1. JUNE, 1908



LOCKING THROUGH THE ST. MARY'S FALLS CANAL

IMPROVEMENTS IN THE ST. MARY'S RIVER

DIAMOND DRILL COSTS

AIR POWER IN A GRANITE QUARRY

LISHED THE SULLIVAN MACHINERY CO. RAILWAY EXCHANGE BUILDING, CHICAGO.

Rogers & Company

TABLE OF CONTENTS

Editorial - - - - - - - - - 201

Improvements in the St. Mary's River - - 202
(SPECIAL CORRESPONDENCE)

The Cost of Diamond Drilling in British Columbia - 210
FREDERIC KEFFER

Air-Power Economy in a Granite Quarry - - 213
(CONTRIBUTED)

The Proper Shape for Rock Drill Bits - - 220
D. J. O'ROURKE

Duty on Diamond Drill Carbon - - - - 224

The Second Raton Hill Tunnel of the Atchison, Topeka and Santa Fe Railway - - - 225
W. P. J. DINSMOOR

MINE AND QUARRY

Vol. III. No. I. JUNE, 1908

A Bulletin of News for Superintendents, Managers, Engineers and Contractors.

Published by the Advertising Department of the Sullivan Machinery Company.

Address all Communications to MINE AND QUARRY, Railway Exchange, Chicago. Sent to any address upon request.

Readers are requested to notify MINE AND QUARRY of any correction or change in address.

THE proper shape for a rock-drill bit, the suitable temper for the steel, and the care and use of drill steel by both blacksmiths and drill runners are important factors in the operation of a machine drill plant which are often neglected, or which at least do not receive the attention and study needful to secure the best efficiency from the machines.

Theory and practice on these points vary in different localities. While readers may not agree in minor points with the article on this subject printed elsewhere in this issue, it is hoped that the ideas expressed may aid in directing attention to this opportunity for increasing the efficiency of drilling work.

THE use of air power in granite quarries is now too common to excite notice, in fact, it is a small, or an old-fashioned concern, indeed, that does not boast an air equipment of some sort. But economy in the production of compressed air is another matter, and one which has only within the last two or three years received proper attention in the stone trade. Too often, inefficient machinery has been installed, and the expected economies not being realized, air power has been decried as an expensive luxury. That this is not the case, when proper equipment is selected, is evidenced by the test upon an air plant at a large New England quarry company, which is reported in another column.

MUCH is heard nowadays of the necessity for deep waterways in the interior of this country, to provide transportation for the masses of low class freight which have overburdened the railroads in recent years. Amid the clamor of commercial associations and cities for a "Lakes to Gulf" route, and other enterprises of like importance, which are still much in the future, the public may lose sight of the extensive work actually being done by the government in another quarter.

The St. Mary's River, connecting Lake Superior and Lake Huron, is one of the greatest inland waterways in the world, from the standpoint of the traffic carried. Through it passes the bulk of the iron and copper mined in the Lake Superior district; the grain harvested in Minnesota, the Dakotas and Manitoba, the flour from western mills, and the coal and general merchandise needed to supply these vast districts. In 1897 the freight tonnage carried on the river was about 19,000,000; in 1907, it had risen to 58,217,214 tons, and in that year 20,437 vessel-passages through the locks were recorded.

The Government is now busily engaged in extensive improvements, which will not only relieve the present congestion of this commercial thoroughfare, but will provide for all increases in traffic, until the growing draught of vessels again requires the deepening of all channels and lake harbors. The description of a portion of these improvements, given elsewhere in this issue, may be interesting at this time.

The new West Neebish channel; the rock section, 8,800 feet long, with channeled walls.

IMPROVEMENTS IN THE ST. MARY'S RIVER.

SPECIAL CORRESPONDENCE OF "MINE & QUARRY."

Sault Ste. Marie, Mich.)

During the past ten years, the volume of vessel traffic passing through the St. Mary's River, between Lake Superior and Lake Huron, has increased with wonderful rapidity. In 1897 it amounted to 19,000,000 tons. In 1907, it had risen to three times that figure. It may be interesting to note that the entire vessel tonnage entering and clearing from United States ports from and to foreign countries amounted, in 1906, to 54,371,320 tons, or only about 10 millions more than the vessel tonnage of the St. Mary's River alone. The freight tonnage of the Suez Canal, in the same year, was 13,445,504, with a total of 3,975 vessels.

The United States Gover ment has been constantly at work, increasing navigation facilities, but the demand has more than kept pace with these improvements. Seventy-five per cent of the entire traffic of the river is borne by the two American locks, the remainder using the canal on the Canadian side.

Improvements now in progress promise to relieve the present situation materially, and to prevent its recurrence. These improvements include the establishing of a complete double channel 600 feet wide and 21 feet deep from the locks to Lake Huron; the widening of the St. Mary's Falls Canal above the locks, and later, the construction of a third lock. River and Harbor work is also being done elsewhere, which will bring the depth of all channels to the standard of 21 feet.

CHANNEL WORK BELOW THE FALLS.

The St. Mary's River and its various channels are shown in the diagram on page 203. Originally, vessels took the circuitous course outside of Sugar Island and Neebish Island. Several years ago a channel was cut between these two islands, connecting Hay Lake and Little Mud Lake, thereby avoiding the long trip outside of Sugar Island. This channel, called the Middle Neebish, has since carried nearly all the traffic. It has disadvantages, however, due to the presence of several sharp turns, with high wooded banks which render approaching vessels invisible to each other; to the rapid current, requiring down-going boats to maintain a speed of eight to 12 miles an hour for steerage way; and by reason of the length and draft of the newer ore carriers, many of which are over 600 feet

long and draw 19 feet or more of water, necessitating careful handling at the turns.

Boats are frequently delayed, in order to make this passage by daylight, and while deliberate caution has kept the number of accidents low, a material hindrance to traffic has resulted.

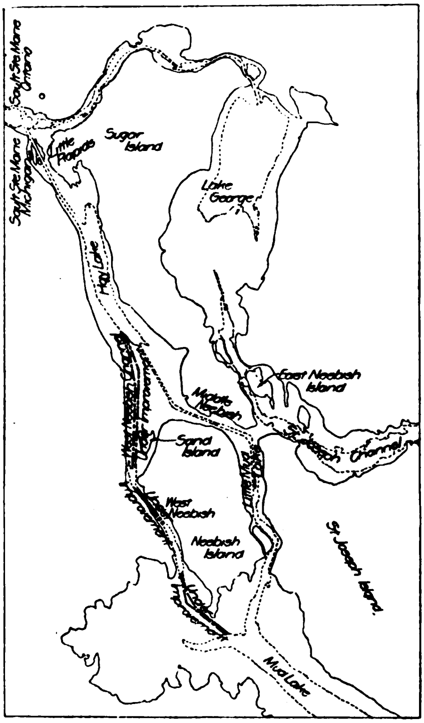
THE WEST NEEBISH CHANNEL.

A channel on the west side of Neebish Island, joining Hay Lake and the north end of Mud Lake, has been placed in service this spring to relieve the situation. The north bound traffic still follows the Middle Neebish route, while all south bound vessels use the new West Neebish course. Contracts will soon be let for the straightening and deepening of the Middle Neebish Channel, involving a large amount of subaqueous rock removal. While this work is in progress, all vessels will take the West Neebish route.

The new cut-off is 13.5 miles long. It will reduce the distance between the locks and Mud Lake by about two miles. The upper and lower reaches of the channel were excavated in the wet with dredges, the material consisting of sand, mud and clay.

ROCK CHANNEL.

The most difficult part of the work consisted in a cut 8800 feet long, and 300 feet wide, which had to be made through solid Niagara limestone, at about the center of the channel's length. The greatest depth of this cut is 28 feet, providing for a minimum depth of 22 feet at low water. The total amount of rock taken out was about 1,700,000 cubic yards. The tenders submitted on this work showed that the expense of excavation by the "dry" method, consisting in laying bare the area by cofferdams and employing open cut practice, would be less than one-half as costly as sub-marine drilling and dredging. The contract was accordingly awarded to McArthur Bros. Co., of Chicago, at $1.36 per cubic yard, on a proposal for excavation "in the dry."



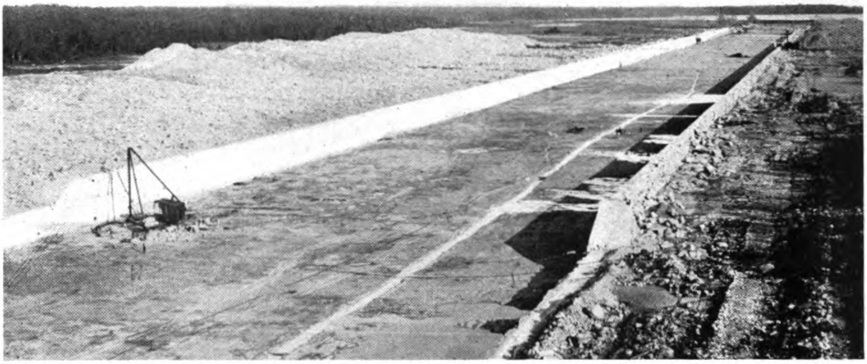
The West Neebish Channel.

(Courtesy of Engineering Record.)

This company sublet the excavation to Grant, Smith & Company of Thorice, Mich., of which Mr. C. H. Locher, an engineer whose high reputation as a rock excavator was established on the Chicago Drainage Canal, is the managing partner. The original contractor agreed to build and maintain the cofferdams.

COFFERDAMS.

Work on the cofferdams was begun in April, 1904. An area about 1000 feet long was first laid bare by constructing two temporary dams across the river, in water from two to seven feet deep. The current ran from three to six miles per hour in this channel. When the water between the dams had been pumped out the excavation of the rock in this section was begun, while the main cofferdams were being constructed at the extremities



The new West Neebish channel; the rock section, 8,800 feet long, with channeled walls.

IMPROVEMENTS IN THE ST. MARY'S RIVER.

SPECIAL CORRESPONDENCE OF "MINE & QUARRY."

Sault Ste. Marie, Mich.)

During the past ten years, the volume of vessel traffic passing through the St. Mary's River, between Lake Superior and Lake Huron, has increased with wonderful rapidity. In 1897 it amounted to 19,000,000 tons. In 1907, it had risen to three times that figure. It may be interesting to note that the entire vessel tonnage entering and clearing from United States ports from and to foreign countries amounted, in 1906, to 54,371,320 tons, or only about 10 millions more than the vessel tonnage of the St. Mary's River alone. The freight tonnage of the Suez Canal, in the same year, was 13,445,504, with a total of 3,975 vessels.

The United States Gover ment has been constantly at work, increasing navigation facilities, but the demand has more than kept pace with these improvements. Seventy-five per cent of the entire traffic of the river is borne by the two American locks, the remainder using the canal on the Canadian side.

Improvements now in progress promise to relieve the present situation materially, and to prevent its recurrence. These improvements include the establishing of a complete double channel 600 feet wide and 21 feet deep from the locks to Lake Huron; the widening of the St. Mary's Falls Canal above the locks, and later, the construction of a third lock. River and Harbor work is also being done elsewhere, which will bring the depth of all channels to the standard of 21 feet.

CHANNEL WORK BELOW THE FALLS.

The St. Mary's River and its various channels are shown in the diagram on page 203. Originally, vessels took the circuitous course outside of Sugar Island and Neebish Island. Several years ago a channel was cut between these two islands, connecting Hay Lake and Little Mud Lake, thereby avoiding the long trip outside of Sugar Island. This channel, called the Middle Neebish, has since carried nearly all the traffic. It has disadvantages, however, due to the presence of several sharp turns, with high wooded banks which render approaching vessels invisible to each other; to the rapid current, requiring down-going boats to maintain a speed of eight to 12 miles an hour for steerage way; and by reason of the length and draft of the newer ore carriers, many of which are over 600 feet

long and draw 19 feet or more of water, necessitating careful handling at the turns.

Boats are frequently delayed, in order to make this passage by daylight, and while deliberate caution has kept the number of accidents low, a material hindrance to traffic has resulted.

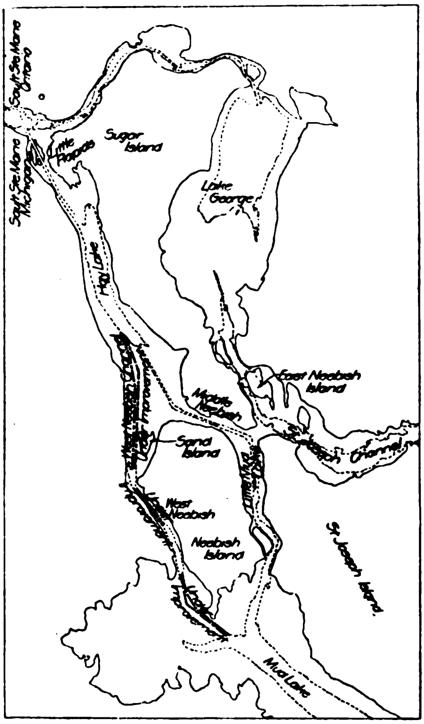
THE WEST NEEBISH CHANNEL.

A channel on the west side of Neebish Island, joining Hay Lake and the north end of Mud Lake, has been placed in service this spring to relieve the situation. The north bound traffic still follows the Middle Neebish route, while all south bound vessels use the new West Neebish course. Contracts will soon be let for the straightening and deepening of the Middle Neebish Channel, involving a large amount of subaqueous rock removal. While this work is in progress, all vessels will take the West Neebish route.

The new cut-off is 13.5 miles long. It will reduce the distance between the locks and Mud Lake by about two miles. The upper and lower reaches of the channel were excavated in the wet with dredges, the material consisting of sand, mud and clay.

ROCK CHANNEL.

The most difficult part of the work consisted in a cut 8800 feet long, and 300 feet wide, which had to be made through solid Niagara limestone, at about the center of the channel's length. The greatest depth of this cut is 28 feet, providing for a minimum depth of 22 feet at low water. The total amount of rock taken out was about 1,700,000 cubic yards. The tenders submitted on this work showed that the expense of excavation by the "dry" method, consisting in laying bare the area by cofferdams and employing open cut practice, would be less than one-half as costly as sub-marine drilling and dredging. The contract was accordingly awarded to McArthur Bros. Co., of Chicago, at $1.36 per cubic yard, on a proposal for excavation "in the dry."



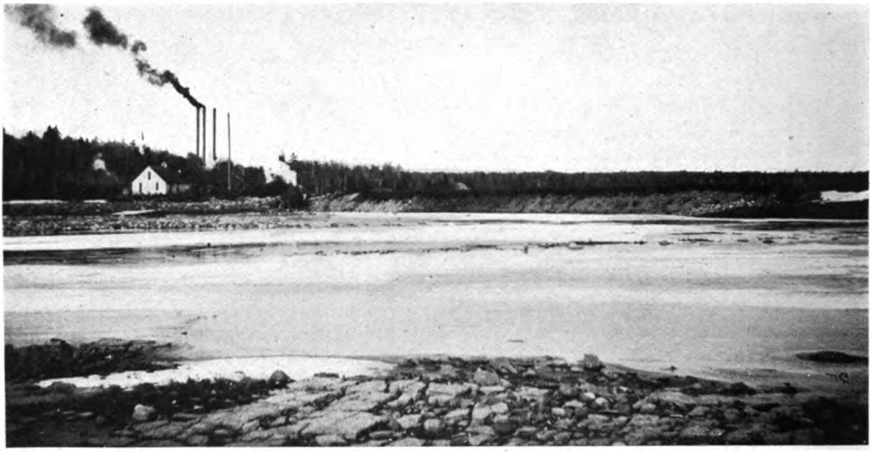
The West Neebish Channel.

(Courtesy of Engineering Record.)

This company sublet the excavation to Grant, Smith & Company of Thorice, Mich., of which Mr. C. H. Locher, an engineer whose high reputation as a rock excavator was established on the Chicago Drainage Canal, is the managing partner. The original contractor agreed to build and maintain the cofferdams.

COFFERDAMS.

Work on the cofferdams was begun in April, 1904. An area about 1000 feet long was first laid bare by constructing two temporary dams across the river, in water from two to seven feet deep. The current ran from three to six miles per hour in this channel. When the water between the dams had been pumped out the excavation of the rock in this section was begun, while the main cofferdams were being constructed at the extremities



The powerhouse and upper cofferdam, West Neebish Channel.

of the portion under contract, in the still water caused by the temporary structures.

These main cofferdams were unusually large affairs. The upper dam was built in water from two to eighteen feet deep, and was 1900 feet long and seven feet wide on top, in its narrowest part. The lower structure was 2600 feet long, 10 feet wide on top and built in water from nothing to 26 feet in depth. The materials used were sandy clay and mud dredged from the channel, and broken rock from the section under excavation. Work on these dams was carried on all winter, in spite of a serious break in the up-stream dam, which flooded the unwatered area. They were completed in April, 1905, at a total cost of about $150,000.

The area between them was unwatered by means of 12 pumps, four of the centrifugal and eight of the ordinary reciprocating plunger type, having a total capacity of 40,000,000 gallons per 24-hour day. The amount of leakage after the first drainage was complete, has been comparatively small.

POWER PLANT.

At the outset it was planned to operate most of the excavating machinery by compressed air. The power plant was installed at the upper end of the work, where a coal supply could be obtained conveniently. This plant consisted of two Corliss cross-compound condensing air compressors, of 4700 and 1900 cubic feet capacity respectively, making the total air power supply, 6600 feet of free air per minute, at 90 pounds gauge pressure. Steam was furnished from suitable boilers at 150 pounds pressure.

An eight-inch main carried the air power along the line of the work, distributing it to the different machines as required. Air reheaters of a special design were used to increase the efficiency of the service. There were 35,000 feet of pipe line of all sizes, entirely exposed to the weather. In winter, fires were maintained at numerous points along the pipe lines, to prevent freezing of the condensation water.

This air supplied about 30 3¼ inch rock drills, used for drilling the blast holes, three eight-inch stone channeling machines, four hammer drills, four cableways, the blacksmith shop, and all except three of the pumps. Each cableway was served by a steam shovel with traction gearing. Some idea of the size and quality of the power plant and equipment

The Steam Channeler (Sullivan Class "Y") beginning the West Neebish cut (1904).

may be gained by stating the purchase price, which was about a quarter of a million dollars.

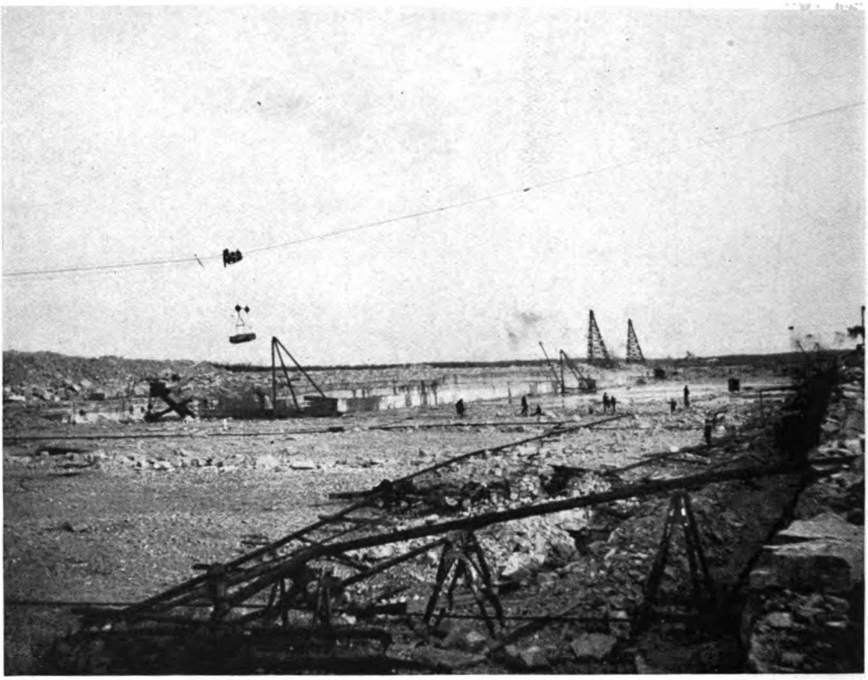
CONSTRUCTION METHODS: CHANNELING.

The rock encountered on this work was hard, compact Niagara limestone. It is very dense, weighing 4,600 pounds to the cubic yard. The walls of the channel are vertical, having been cut out of the solid rock by means of stone channeling machines. Their smooth, uniform faces present a neat, finished appearance, and the flow of the water will be less retarded than if the walls had been drilled and blasted. Vessels will also sustain less damage if they rub the walls, and the latter, being unshattered by powder, will always remain in their present solid condition.

This work was done with one Sullivan Class "Y-8," eight-inch channeler, operated by air power, one Sullivan Class "Y" seven-inch channeler, which carried its own boiler, and two eight-inch air channelers of another make. The three air channelers were equipped with air reheaters. In winter they were provided with board shelters, to protect the operators. These machines are shown at work on pages 205 and 207. The channelers were capable of cutting to a depth of 14 feet, and in most cases put down two lifts. The depth of the cut varied from zero at the ends to 27 feet in the center, with an average depth of 15 or 16 feet. In all, over 200,000 square feet of wall were channeled. An average day's run for the machines was from 75 to 100 feet, although on test runs, the Sullivan machines cut as high as 205 feet.

ROCK DRILLING.

The 3¼-inch rock drills put in holes from 12 to 16 feet deep, at the corners



The West Neebish channel in process of construction. The channel cut may be seen close to the right wall.

of 4x6 foot or 5x5 foot squares. This close arrangement was required by the dense nature of the rock, and made the cost of blasting high. The engineers' records show that about three-quarters of a pound of dynamite, (one-half 60 per cent. and one-half 40 per cent.) was required, per cubic yard. Half of the face of the cut (150 feet) was shot at a time, so that the shovel could remove the muck from one side while the drills were at work on the other.

An average shift's work, both winter and summer, was about 40 to 60 feet of drilling per machine. The holes were charged with dynamite, and fired by electricity. In some cases it was necessary to break up the larger fragments before they could be loaded, and this was done by pop shots, placed in holes drilled by air hammer drills.

STEAM SHOVELS.

The broken rock was loaded into skips by four 60-ton steam shovels, propelled by traction gearing on wheels with 30-inch tires. This is the first case, that has come to the writer's attention, in which traction shovels have been used upon work of this character. The rock, as it stood in place, was frequently intersected by horizontal planes, so that the bottom and benches of the cut were nearly as smooth and level as a ball-room floor. This was particularly advantageous for these shovels, which were rarely stalled by rough or broken ground. The shovels were supplied with boiler feed water by a two-inch pipe line from a pump midway in the cut. These pipe lines, which were from 2000 to 5000 feet long, were laid on the ground, without protection from the weather. They were

blown out each time after use, to prevent freezing, by compressed air, admitted through a one-quarter inch orifice. The air was turned on as soon as the pumps stopped. This plan was so successful that during the two winters only about one day was lost to each shovel, from this cause.

CABLE WAYS.

Each shovel served one of the four cable ways, of which two had a span of 1100 and two 800 feet each. The rock was handled in skips holding six cubic yards, but single fragments containing seven to eight yards, or 18 tons, have been carried without apparent difficulty. An aerial dumping device, invented by Mr. C. H. Locher, increased the speed with which the spoil was removed.

One of these cable ways has a record of 30,000 yards removed in one month, while the best record for one month for the entire plant consisted in the removal of 88,000 cubic yards of rock.

Retaining walls have been built along both sides of the channel for a distance of 5000 feet. These walls are from five to 20 feet high and five feet thick at the top. They are made of stone taken from the cut, and from small quarries along the work. Their tops are about six feet above extreme low water, or three feet in summer, and will serve as a guide for the vessels using the channel.

CONDUCT OF THE WORK.

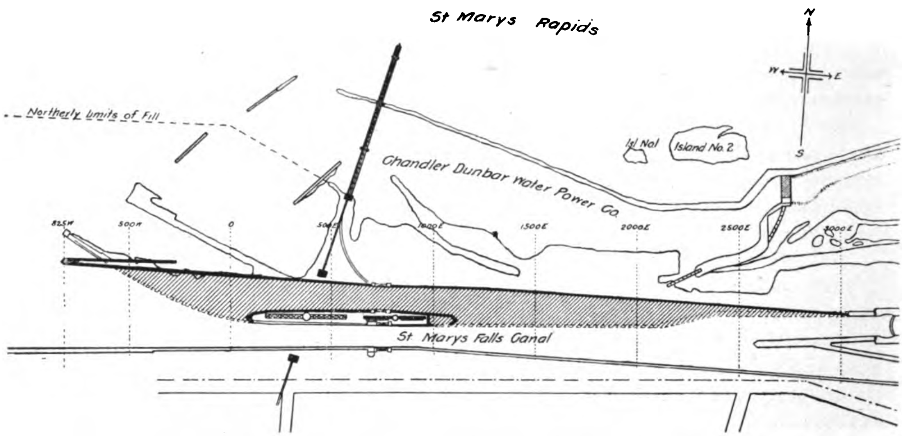
This work was practically finished before the close of navigation last fall. Its early completion, nearly a year ahead of time, reflects great credit on the contractors and their methods and organization. Work has been carried on day and night, practically without interruption, except on Sundays. During 1906, the government engineers credited the contractors with 290 working days. In this climate the winter is six months long, and the thermometer often registers from 10 degrees to 20 degrees below zero, while frequent snow storms keep the ground covered two to three feet on a level.

That work should have been kept up day after day under such conditions indicates uncommon energy and ability. One secret of success in the conduct of this work was the unusually thorough system of inspection, and the high standard of repairs applied to all items of the plant. Special mechanics were detailed to the various classes of the machinery composing the equipment, and prompt attention was given to troubles as soon as they appeared.

Supplies for the three camps and for the power plant were brought 17 miles from Sault Ste. Marie, by boat in summer, and by sleigh, overland in winter.

The improvement of the West Neebish Channel was executed under the direction of Col. C. E. L. B. Davis, corps United States engineers; Mr. L. C. Sabin, Assistant U. S. Engineer with headquarters at Sault Ste. Marie; and Mr. Sutton Van Pelt, in charge under Mr. Sabin. Mr. A. S. Robinson, Sault Ste. Marie, was local manager for MacArthur Bros. Co.

Sullivan "Y-8" Channeler with air reheater on the West Neebish cut.



St. Mary's Falls Canal, showing the proposed improvement. The upper approach to the U. S. locks is seen at the right.

ST. MARY'S FALLS CANAL.

On March 5th of this year, the U. S. Government engineers awarded a contract for widening St. Mary's Falls Canal above the locks at Sault Ste. Marie, to the Great Lakes Dredge & Dock Co., of Chicago, on the basis of the following bid:

Dirt excavation and dredging, 135,000 cubic yards at $0.55; rock excavation, 360,000 cubic yards, $1.30; rock channeling, 85,000 square feet $0.30; revetment walls, timber work, 150,000 cubic feet, $0.10; filling above with stone, 20,000 cubic yards, $0.30; concrete, 7,000 yards, $4.00; and special concrete, 9,500 yards, at $5.00 per yard.

The work to be done is shown by the sketch, taken from the specifications, on this page. It consists in excavating and removing material from an area about 3700 feet long, averaging about 125 feet wide and 30 feet deep, and in building about 1400 linear feet of timber crib walls and 3700 linear feet of concrete walls.

The United States has constructed a cofferdam at the upper end of the work, which will permit most of the excavation to be carried on in the dry, the contractor being called upon to furnish and maintain an adequate pumping plant.

The rock material to be removed is largely Potsdam sandstone, some of which is hard, while other portions are soft and seamy. The rock walls will be channeled so as to leave a smooth face. The work also includes constructing timber cribs, filled with stone and concrete revetment walls.

In order to avoid interruption of traffic while this improvement is being made, a rib of rock about 40 feet wide will be left between the present canal and the excavation. This rib is indicated by the dotted line near the lower edge of the section to be excavated, shown on the above sketch.

The government specifications require that both this wall and the new outer wall of the canal shall be channeled, and not drilled and blasted, in order to avoid shattering of the walls, and weakening of the rock behind them. Smooth walls are also required to reduce the danger of injury to vessels, when they come in contact with the walls. The rib above mentioned, together with the connections to the canal proper, will be blasted out during the winter of 1909 and 1910, when the passage is closed to navigation.

The contract requires the contractor to start work within 60 days after having been awarded the contract and to complete the job on or before June 30th, 1910.

Mr. T. C. Lutz, Vice President of the Great Lakes Dredge & Dock Co. will have general charge of the work, being efficiently assisted by Mr. Thomas H. Mackie, local manager at Sault Ste. Marie. After careful investigation, the company concluded to operate the channelers by steam and the rock drills by means of compressed air and has closed a contract with the Sullivan Machinery Co. for the following plant:

One 22x14x18 inch duplex belt driven air compressor, Class "WJ". This compressor is of the familiar duplex type with cross compound air cylinders, wherein the air is compressed in two stages with intercooling, thus saving about 15 per cent. in power consumption over simple compression. The main bearings, cranks, eccentrics, guides and crossheads are enclosed in a dirt-proof casing. This housing will be partially filled with oil, making the machine self-oiling and thus requiring little attention. The compressor will be driven by belt from a 150 K. W. motor of the synchronous type and will take alternating current at 4000 volts. The electric power will be furnished by the Soo Edison Co., whose new water power plant is near by. A four-inch pipe line will run along the line of work, transmitting power from the air compressor to twelve Sullivan "UF-11" 3¼ (inch) tappet valve rock drills, mounted on tripods.

Sullivan channelers were selected for the work by reason of their showing at the West Neebish cut, described above.

The contractor's equipment also includes two steam shovels, which are already at work, stripping the seven to nine feet of earth which overlies the rock; four dinkey locomotives, and a large number of dump cars.

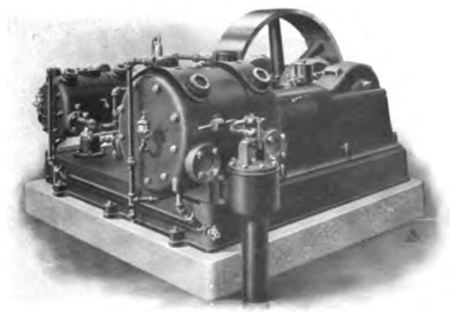
The power plant will be installed within the next 60 days, and drilling and channeling will begin about August first.

DETROIT RIVER WORK.

A second channel, for down-going traffic, is also being excavated in the Detroit River, across a bend in the stream, now consisting mainly of swamp land. This somewhat resembles the West Neebish work, consisting of a channeled rock section in the center, with earth sections, to be excavated by dredges in the wet, at either end.

Messrs. Grant, Smith & Co. have secured the contract for the dry section and have moved their air compressor plant, drills, channelers and steam shovels to this new location, from Thorice, Michigan.

We are indebted to Mr. Sutton Van Pelt, U. S. Corps of Engineers, for photographs and information used in this article. Acknowledgment for assistance in its preparation is also tendered to Mr. C. H. Locher, of Grant, Smith & Co., and to the *Engineering Record*, of New York.



Two-stage Duplex Belt-driven Compressor, Class "WJ."

THE COST OF DIAMOND DRILLING IN BRITISH COLUMBIA.*

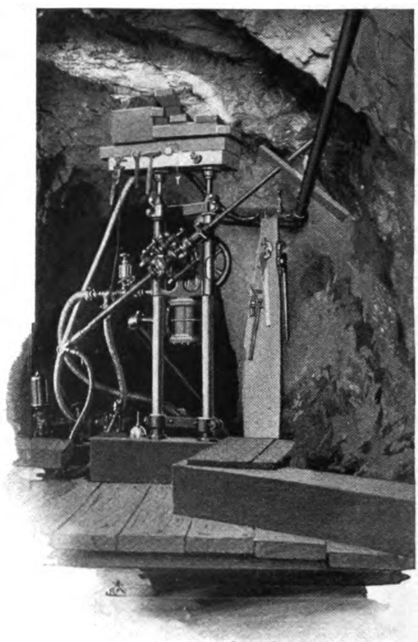
Two years ago I contributed to the Institute a paper on the results of diamond drilling as carried on at the mines of the British Columbia Copper Company, Limited, during 1905. That paper gave some details as to costs, and the period covered was but 8½ months. Since that year drilling has been carried on more or less continuously in the mines of the company, and the results of this work, so far as progress and costs are concerned, are given in detail in the following tables.

The Progress Table gives the monthly results of work as well as the yearly totals. It is of course important to know the general character of the rock drilled in order to institute comparisons with other localities. In the narrow limits of this table it is not possible to give details as to rocks, but as nearly as possible the rocks comprise diorites, compact garnetites and certain very hard and silicious eruptives occurring in Summit camp. The medium hard rocks include all ores, and, in Deadwood camp, much of the greenstone country. The soft rocks are the limestones, porphyries and serpentines. Of all rocks drilled the garnetites proved much the most severe in diamond consumption, as is illustrated by the work from May to August, 1907, which was mainly conducted in garnetite with some silicious limestones.

Eight hours constitute a shift underground, and nine hours on the surface. On Sundays no work is done apart from repairs to machinery. In May, 1906, the labor was contracted as an experiment, but was abandoned as being unsatisfactory.

(* NOTE:—A paper read before the Canadian Institute of Mining Engineers at its meeting in Nelson, B. C., January, 1908, by Mr. Frederic Keffer, Engineer of the British Columbia Copper Co., Greenwood, B. C. The substance of Mr. Keffer's previous article was given in "Mine and Quarry" for February, 1907.)

The Cost Table gives details of costs under the four groups of Labor, Power, Repairs, Oils, etc., and diamonds. The employes were, normally, a runner and a setter. Extra help was required at times for blasting places for good set ups, for laying pipe lines, moving plant, etc. In August, 1907, two shifts were employed. In June and July of that year the increase in labor costs is mainly on account of the long pipe lines required. The power consumed is taken as being equivalent to that required for a 3¼-in. machine drill, that is to say, about 20 H. P. When drilling at a mine, where for example 15 machines are used on each shift, the diamond drill is charged with 1-31 of the total power costs—it being in this intance run on one shift only.



A Sullivan Diamond Drill drilling an upper hole in a British Columbia Mine.

TABLE I.—PROGRESS TABLE

Date	Depth of Holes: Vertical feet	Horizontal feet	Total feet	Hours actual drilling	Hours moving to new holes, setting bits, etc.	Total hours	Number of holes	Shifts	Feet per shift	Feet per drilling hour	Character of Rock	Remarks
1906												No.
Jan	170	0	170	106	46	152	6	19	8 94	1 60	Mainly hard diabase 1	1 – Hard Rocks.
Feb	0	191	191	104	24	128	3	16	11 93	1 83	Softer lime rock 3	2 – Medium hard rocks. 3 – Soft rocks
March	332	66	398	205	77	282	5	33	12 06	1 94	Equal parts of above rocks 2	
April	214	0	214	76	55	131	7	16	13 37	2.81	Lime rocks and ore 2	
*May	390	73	463				4				Nearly all in ore 2	
June			0									No work in June and July.
July			0									
August	0	508	508	160	48	208	7	26	19 59	3 17	Fairly hard rock 2	
Sept	0	96	96	29	3	32	0	4	24 00	3.31	Mainly ore 2	Drill men off on vacation.
Oct	195	40	235	95	53	148	4	17	13 82	2 45	do 2	
Nov	33	378	411	157	63	220	6	27	15 22	2 62	Hard silicious rock 1	
Dec	189	127	316	144	48	192	3	24	13 17	2 19	do do 1	
	1523	1479	3002	1076	417	1493	45	182	Av. 13 59	Av. C. 2.359		C.—Averages calculated on 3.002 ft. less 463 drilled on contract.
1907												
Jan	246	165	411	159	57	216	6	27	15 22	2 58	Limes and porphyry 3	
Feb	0	378	378	137	79D	216	2	27	14 00	2 76	Ore and limy rock 2	D.—Several days lost moving 15 miles to another mine.
March	200	340	540	180	28	208	5	26	20 77	3.00	do do 2	
April	278	186	464	181	27	208	1	26	17 86	2.56	do do 2	
May	67	433	500	163	53	216	3	27	18 52	3.07	Hard garnetite 1	
June	189	288	477	187	39	226	6	26	18 34	2.55	Very hard garnetite 1	
July	96	304	400	203	23	226	6	27	14 81	1 97	do do and diorites 1	B.—Much trouble with caving ground in August. Worked two shifts nearly all the month.
Aug	497	0	497	213	129B	342	8	38	13 18	2 33	do do 1	
	1573	2094	3667	1423	435	1858	37	224	Av. 16 34	Av. 2.577		

(*) This month's work was contracted as to the labor. Feet drilled are therefore not included in averages as contractor worked overtime.

TABLE III.—SUMMARY OF PROGRESS.

Year	Feet Drilled: Vertical	Horizontal	Total	Hours: Drilling	Moving, etc.	Total	Number of Holes	Number of Shifts	Feet per Shift	Feet per Drilling Hour
1906	1523	1479	3002	1076	417	1493	45	182	13.59	2.359
1907	1573	2094	3667	1423	435	1858	37	224	16.34	2.577
	3096	3573	6669	2499	852	3351	82	406	15.285 A.	2.482 B.
	Contract Feet.		463							
Feet used in calculating averages A. and B.			6206							

TABLE II.—DIAMOND DRILLING COST TABLE FOR 1906.

Date	Labor Cost	Cost per foot	Power: Kind	Cost	Cost per ft	Repairs Oils, etc	Cost per foot	Diamonds: Carats used	Market price	Cost	Cost per ft	Total Costs	Total per foot	Feet drilled	Remarks
1906															
Jan	172 00	1 012	Elec A	36 30	213	22 72	133	61 64	56 53	53 99	318	285 01	1 676	170	A.—"Electric power" is compressed air from electric driven compressors.
Feb	152 50	798	do	32 10	165	7 01	036	3 47/64	"	206 70	1 082	398 31	2 081	191	Costs reckoned on assumption that diamond drill consumes as much power as a machine rock drill; that is approximately 20 H. P.
March	292 00	734	do / steam	112 20	282	68 60	172	3 35/64	60 07	213 07	535	685 87	1 723	398	
April	188 87	882	Elec	31 58	147	26 93	126	1 59/64	"	115 45	539	362 83	1 694	214	
May	480 48	1 037	do	38 53	083	19.41	042	5 36/64	"	334 15	722	872 87	1 885	463	Labor contracted this month
June															No drilling done.
July															do do
Aug.	269 25	.530	do	52 95	104	30.67	060	3 25/64	60 07	203 68	.401	556.55	1 095	508	
Sept.	52 85	551	do	5 07	.053	.00	00	46/64	"	43.17	.449	101 09	1.053	96	Drill men on vacation
Oct.	163 60	781	do	51.12	.217	2 29	.009	2 19/64	61 90	141.70	600	378 71	1.610	235	
Nov.	280 10	681	Steam	127 42	310	115.18	288	2.40/64	"	160.50	.390	686 20	1 669	411	Drill operated most of Nov. and Dec. by steam direct from boiler.
Dec	288 00	911	Steam	128 32	.406	34 21	108	4 8/64	"	255 24	.808	705.77	2.233	316	
	2359 65	Ave 786		615 89	Ave. .205	330 02	Ave 109	28 56/64		1727 65	Ave. 576	5033 27	Ave. 1 676	3002	

TABLE II.—DIAMOND DRILLING COST TABLE FOR 1907.

Date	Labor Cost	Cost per foot	Power: Kind	Cost	Cost per ft	Repairs Oils, etc	Cost per foot	Diamonds: Carats used	Market price	Cost	Cost per ft	Total Costs	Total per foot	Feet drilled	Remarks
1907															
Jan	264 25	.643	Steam	236 24	575	13 37	032	1 3/64	61 90	62 89	153	576.75	1 403	411	
Feb.	245 10	648	Elec.	68 60	.182	5 45	014	1 50/64	80 00	141 70	.375	460.85	1 219	378	Great advance in price of diamonds.
March	265 75	.492	do	53 34	.099	26.23	049	2 37/64	"	219 14	405	564.46	1.045	540	Best month on record for low total costs.
April	277.90	.599	do	51 13	.110	7.31	015	3 18/64	"	262 50	566	598.84	1.290	464	
May	332 00	.664	do	58 85	.117	6 38	013	5 4/64	"	405 48	810	802.71	1 604	500	
June	397 55	.833	do B	175 00	.367	47 92	100	5 16/64	71 75	376 36	790	996 83	2 090	477	B.—Increase in power cost due to partial closing of mine, throwing more costs on the power for diamond drilling.
July	402 56	1.006	do B	182 25	.455	164 83	412	7 3/64	"	511 88	1.79	1261.52	3 153	400	
Aug	439 22	883	do B	200.00	.403	93.78	189	4 44/64	"	342 77	689	1075 77	2 164	497	June, July and August were drilling in very hard garnetite increasing diamond consumption.
	2624 33	.715		1025.41	Ave. .280	365.27	Ave. .100	30.47/64		2322.72	Ave. .633	6337.73	Ave 1.728	3667	

SUMMARY—COST 1906-7.

Labor, total cost	$4983.98
Labor, cost per foot	.747
Power, total cost	1641.30
Power, cost per foot	.246
Repairs, Oil, etc., total	695.29
Repairs, Oil, etc., per foot	.105
Diamonds, total carats	59.609
Diamonds, carats per foot	.00893
Diamonds, total cost	4050.37
Diamonds, cost per foot	.607
Total cost of drilling	11370.94
Total cost per foot	1.705

Where steam power is used either directly or through a steam driven air compressor, the costs are much increased. Where, as in some cases, an isolated 24-H. P. boiler was used, the power costs are still higher, as an engineer has to be provided as well as a team to haul wood.

Tools, repairs, etc., include these items as well as all small miscellaneous expenses. The increasing cost of diamonds added materially to the cost per ft. in 1907.

The third table is a summary of the first two, and shows an average cost per ft. for the two years of $1,705. The carats used per ft. are 0.572/64, or in more intelligible decimals, .00893 carats, so that one carat on the average drilled 111.9 ft. All holes over 30 degrees dip are classed as vertical, and ft. per hr. in horizontal holes is about 15 per cent greater than in vertical ones. The average depth of holes is 81.3 ft., and diameter of cores is 15/16 ins.

In comparing these costs with contractors' prices, it must be borne in mind that contractors usually require air (or steam) and water to be piped to the work, and the mine must in addition furnish the air and water free of charge. In the present cost sheets all these items are charged against costs of drilling.

(The following information did not appear in Mr. Keffer's original paper—It is quoted from *Engineering Contracting*.)

The drill runner set and was responsible for the diamonds. He was paid a salary of $175 per month, while two helpers, during the period of time given, received $3.50 per day. Since the decline in the price of copper, helpers are only paid $3.30 per shift. The compressor men receive $4 per day.

Wood for fuel costs from $3.50 to $5 per cord according to locality and difficulty of cutting and hauling. Electric power costs $33 to $40 per horsepower per year according to locality.

This drilling was done with a Beauty drill, of the Bullock type, manufactured by the Sullivan Machinery Co. of Chicago, Ill. This machine has been in service three years and is in excellent condition. Many of the rods bought with the machine are still in service, though naturally the life of the rods is short compared to that of the drill.

The catalog price of this drill with the equipment that is furnished with it is $1,500. This does not include carbons but does include 2 bits ready to have carbons set in them. The shipping weight of this outfit is 1,160 lbs. This drill is adapted both to mine drilling and surface drilling, as it will drill to a depth of 800 ft., making a hole 1 9/16 inches in diameter and giving a 15/16-inch core. It is well adapted to drilling in hard rock.

Mr. Keffer estimates that with proper usage the depreciation on this plant should not exceed 10 per cent per annum. This does not include the cost of carbons which is given in the tables. For depreciation of plant and interest at 6 per cent, a yearly charge of $240 must be added to the costs given in the tables.

Finishing plant and docks of the Rockport Granite Co., Bay View, Mass.

AIR POWER ECONOMY IN A GRANITE QUARRY.

The Rockport Granite Company, at Rockport, Mass., one of the oldest and largest granite firms in the country, has been a user of air power in its quarries and sheds for a number of years, and presents one of the best examples to be found, of intelligent planning and efficient management in its methods and equipment.

This company owns 500 acres at the extremity of Cape Ann, about three miles from Gloucester. It has ten openings or pits in operation, at Rockport, Pigeon Cove and Bay View, and large finishing sheds at Rockport, and at Bay View. There is also a large quarry at Jonesport, Me., from which a handsome red granite is shipped to Rockport for finishing. The company employs over 500 men. Air power has been used for several years at the Rockport quarries and sheds, being furnished by a 1300-foot compressor at the main opening and by two 550-foot compressors at the newer "Farms" quarry.

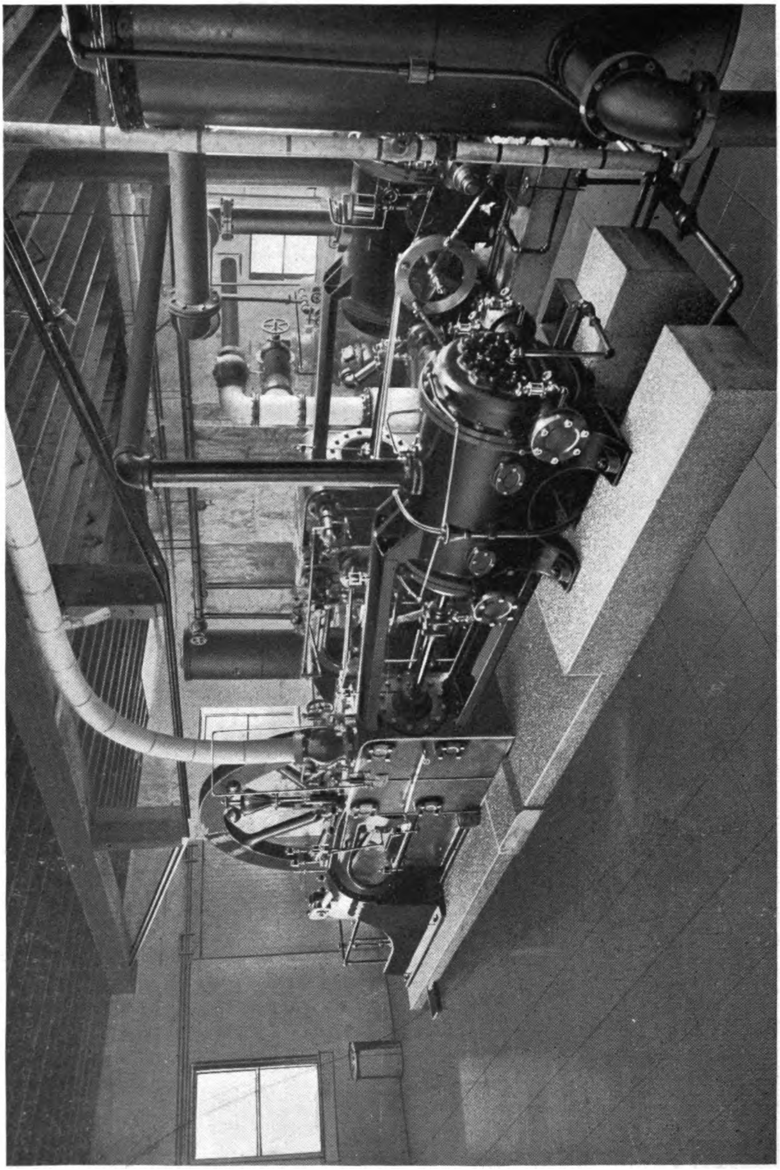
BAY VIEW QUARRIES.

At Bay View, three miles west of Rockport, on the other side of the cape, there are four quarry pits, and the main finishing plant of the company. This plant includes a mill 150 feet long, containing polishing machines, a surfacing machine, a gang saw and a large lathe; and a cutting shed, the enclosed part of which is 240 by 65 feet. This shed is immediately on the water front, adjoining the shipping dock. The stone is handled from the quarry cars to the shed and from the shed to the dock by a locomotive crane.

POWER PLANT.

The company, about a year ago, installed one of the largest air plants in New England, to operate the machinery in these quarries and sheds. It consists of a Sullivan-Corliss cross compound two stage air compressor of 1600 cubic feet capacity. This machine is illustrated on pages 214 and 218. It is installed on a solid concrete foundation, in a granite power house, shown on page 218.

This plant supplies air to the four quarries and the cutting sheds. It operates six hoisting engines, averaging 7x10 inches in size, a small stationary engine, between 30 and 40 Sullivan "plug" drills several large rock drills, and five pumps in the quarries, and two surfacers, five Sullivan "plug" drills and about a dozen



Sullivan Class "WX" Corliss Air Compressor at the Bay View quarries of the Rockport Granite Co.

hand tools in the shed. The air is distributed from the compressor in a five-inch main 3600 feet long and a four-inch main 1200 feet long. Branch mains of three and 2½ inch diameter aggregate 3734 feet. There are also 1300 feet of 1½ inch supply pipe, 2000 feet of 1¼ inch, and 1700 feet of one-inch lines.

To secure the greatest possible efficiency from the air, nine reheaters are installed, at various points in the quarries, and one in the shed. Five of these were made by the Rockport Granite Co., in their own machine shops, and five by the Sullivan Machinery Co. They are rated at a capacity of 250 feet of air cubic per minute each.

In equipping this plant, the company spared no pains to establish a working equipment which would permit the production of stone upon the most economical basis possible. Their attention was addressed particularly to the power plant, and the boilers, air compressor and auxiliaries are all of the most efficient type which they could procure. In order to determine the degree of success which they had attained in this object, a test was made, on January 9th and 10th, 1908, to ascertain the commercial economy and efficiency of the air plant. This test was conducted by engineers of the Sullivan Machinery Co., assisted by representatives of the Rockport Granite Co., and of the manufacturer whose instruments were employed in making the test.

THE COMPRESSOR.

The air compressor consists of a Sullivan Corliss Cross Compound condensing steam engine, with two-stage air cylinders. The low pressure air cylinder is placed tandem with the low pressure steam, and the high pressure air cylinder tandem with the high pressure steam cylinder. Its general dimensions are as follows:

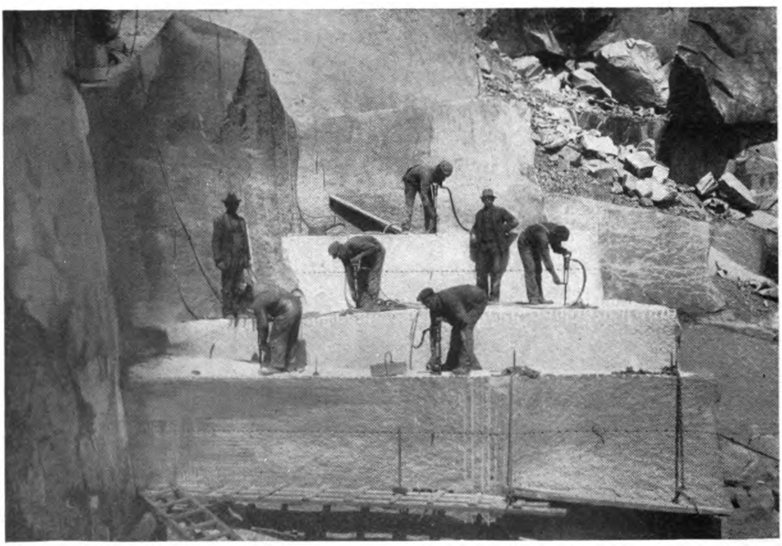
High Pressure Steam Cyl.	13 in. diam.
Low Pressure Steam Cyl.	26 in. diam.
Low Pressure Air Cyl.	24 in. diam.
High Pressure Steam Cyl.	15 in. diam.
Length of stroke	36 inches.

Displacement capacity, 1617 cubic feet of free air per minute, at 86 R. P. M., against 100 pounds terminal air pressure. The steam valve motion for both the steam cylinders is of the full Corliss pattern, the automatic cut-off being actuated by dash-pots. The engine is governed by a weighted fly-ball governor, whose effect is to hold the engine speed constant as the air pressure varies. It works in unison with an automatic air pressure regulator, which reduces the speed of the compressor as any desired limit in the pressure is approached. Both the governors operate by lengthening or shortening the cut-off of the compressor.

A steam receiver is situated between the high and low pressure steam cylinders, for reheating and drying the steam in its passage from one to the other. The compressor is operated condensing, a jet condenser and air pump giving the vacuum. The air pump takes its steam from the reheater coil.

Air is admitted to both air cylinders by means of positively operated semi-rotary valves, and discharged through automatic poppet valves in the cylinder heads. Both the cylinder bodies and heads are supplied with water-jackets, to remove the head of compression. Further cooling is secured by a large receiver.intercooler, placed between the low and high pressure cylinders, and by a receiver after cooler through which the air passes on leaving the high pressure cylinder. Drains are provided at the foot of each cooling tank, so that practically all water vapor is removed from the air before it enters the pipe line. This obviates the danger of freezing at the exhaust ports of the drills and other air-driven machinery. The steel cooler shells or bodies contain groups of copper tubes for the circulating water, and baffle plates cause all the air to cross the tubes in thin sheets during its passage.

A general view of one of the quarries.



Sullivan "D-15" Hammer Drills in the Bay View Quarries.

The boiler is of the return tubular type, fitted with an arch protector and a damper regulator. The auxiliaries consist of a duplex outside plunger pot valve steam pump for boiler feed; two duplex steam pumps for the water circulation, through the compressor cylinder jackets, intercooler and aftercooler; a simple steam pump for removing the condensed steam and cooling water from the condenser, and for maintaining the vacuum, and two feed water heaters.

The boiler feed water is drawn from a concrete cistern, which takes its supply from a small brook near the power plant, dammed up to form a permanent reservoir. The feed water passes first through a heater placed between the low pressure steam cylinder of the compressor and the condenser, and then through an auxiliary heater of the same pattern, receiving the exhaust steam from the pumps. A part of the cooling water from the aftercooler and from the intercooler was used as feed water for the boiler in the first and second day's test, respectively.

CONDITIONS OF TEST.

Two separate tests were run, the first on January 9th, and the second on January 10th. During the first day's test, the regular service conditions of speed, pressure and air consumption were observed, while on the second day, a nearly constant speed was maintained. When the compressor was delivering more air than could be used, the surplus was allowed to escape into the atmosphere. The tests were run continuously from 8:30 a. m. until 4:00 p. m. on the first day and from 8:10 a. m. until 4:10 p. m. on the second day. On the second day the speed of the air pump was reduced, as it was found that more cooling water than necessary was being used. This, together with the higher steam pressure and constant speed, accounts for the lower steam consumption on that day.

METHODS EMPLOYED.

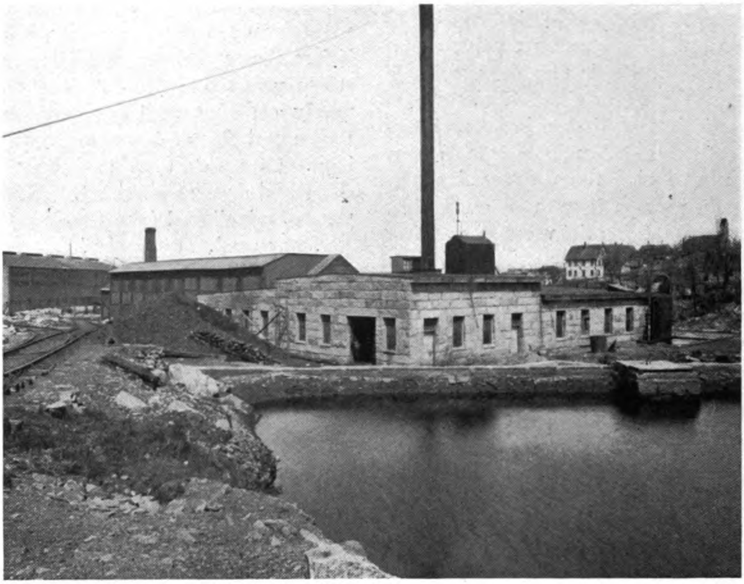
All steam and water piping, glands and valves were inspected and made tight before the test, to prevent leakage. The steam pressure on the first day was held nearly constant at 140 pounds, and on the second day at 145 pounds per square inch. Care was used to keep the fires clean and even at all times. Bituminous "run of mine" coal from Cambria County, Pa., was used. Its analysis shows a fuel value of 15,000 British thermal units per pound. All gages, thermometers, calorimeters, indicator springs and other instruments were carefully tested and standardized for this test, and found to be without appreciable error. Eight indicators were used in taking readings, one at each end of each cylinder of the compressor. Revolution counters were attached to the compressor and each of the pumps. Cards were taken every ten minutes, and readings were made from the counters, steam and air pressure gauges, and of the temperatures of the air at all stages of its passage through the compressor, and also of that of the cooling water and feed water.

The compressor ran at an average speed of 77.21 revolutions per minute on the first day, and of 78.04 on the second, the piston speed being 463.26 feet and 468.24 respectively. Air was compressed to an average pressure of 92.47 pounds per square inch in the first test and of 100.05 in the second.

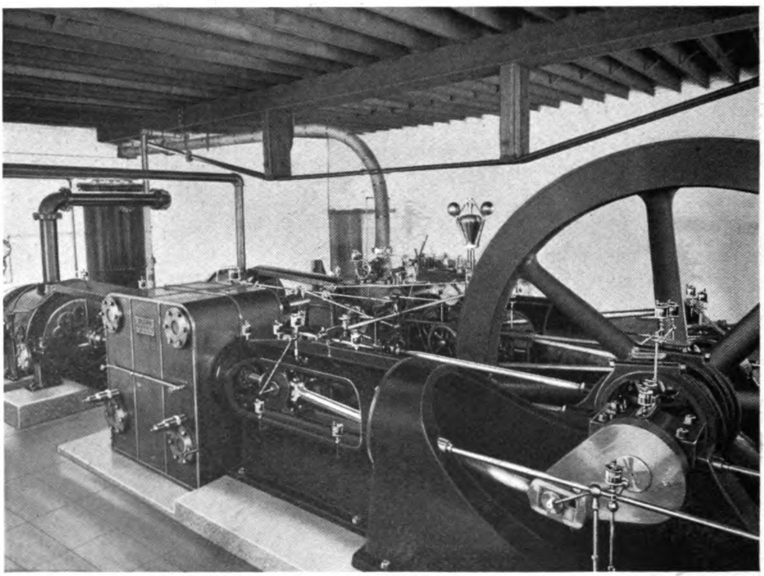
RESULTS.

The results of the tests were as follows:

	Jan. 9	Jan. 10
Steam consumption for compressor, per indicated H. P. per hour, pounds	14.56	14.25
Steam consumption for entire plant	18.75	17.95
Coal consumption for entire plant per indicated H. P. per hour, pounds	1.881	1.844



Bay View powerhouse and finishing plant of the Rockport Granite Co.



Low-pressure side of the Sullivan Air Compressor.

Indicated H. P. required to compress 1000 cubic feet of standard free air per hour from atmospheric pressure to 100 pounds gauge pressure per square inch......	3.124	
Mechanical efficiency of compressor per cent....	88.4	89.3

The mechanical efficiency of the compressor was, probably decreased three or four per cent, owing to the fact that an improper lubricating oil was used in the steam cylinders, so that the automatic sight feed oilers could not be used. A careful test of the boiler plant showed an evaporation of water per pound of coal actually used, of 10.21 pounds on the first day and 10.03 on the second. The thermal efficiency of the boiler was 66.7 per cent. and 65.8 per cent. on the two days.

COST OF COMPRESSING AIR.

From these tests, the cost of compressing 1000 cubic feet of standard free air, from atmospheric pressure to 100 pounds per square inch (gauge) was calculated to be $.011065. This is based on the total coal consumption and includes the cost of operating the auxiliaries. Lubricating oil and labor are not included in these figures.

PRODUCT.

The stone produced by the company is very hard and holds its color well. It is free from iron, and has a crushing strength of about 23,000 pounds to the inch. It is principally used for buildings, bridges and heavy granite construction of all kinds. More paving blocks are made here than anywhere else in New England. The Jonesport Red Granite was employed in the Real Estate Trust Co.'s building, the Siegel-Cooper Building, New York, the Suffolk County Court House, Boston, and the American Baptist Publication Building, Philadelphia. "Bay View Gray" may be seen in the Boston and Baltimore Post Offices, in the eight towers of the Cambridge bridge at Boston, and the Registry of Deeds of Essex County, at Salem, Mass. "Bay View Green" has been effectively used in the columns of the Madison Avenue Presbyterian Church, in New York, and in the Logan Monument, in Chicago. The company is now supplying stone for the Manhattan Anchorage of the Williamsburg Bridge, for the National City Bank building at New York City, and for a large sea wall at the Kittery, Me., Navy Yard. The waste rock is sold as crushed stone.

ROCKPORT QUARRIES.

The main office of the company is in an ivy-covered granite building, at Rockport, on the brow of a hill overlooking to the East, the stone yard where the paving blocks are cut, the finishing shed, and the shipping docks, along the water's edge. The large quarry (see page 216) is about 300 yards to the west. At the Farms quarry, a mile further out on the cape, many improvements are being made. The stone here lies in sheets, permitting blocks of any dimensions to be gotten out very economically.

QUARRY FACILITIES.

Nearly all the product from the quarries is shipped by vessel from the company's three private docks, which have a capacity of 1200 tons each, per day. Ten vessels are owned by the company and a number of others chartered for their exclusive use. The quarries, stone sheds and yards and docks, are connected by about six miles of railroad track, also the property of the company, together with locomotives, cars and locomotive cranes for handling the granite.

The officers of the Rockport Granite Co., are C. Harry Rogers, President, Rockport, Mass., and Chas. S. Rogers, Treasurer and General Manager. The company maintains branch offices at 31 State street, Boston, and 21 Park Row, New York. It is capitalized for $300,000 and was organized in 1864.

THE PROPER SHAPE FOR ROCK DRILL BITS.

WRITTEN FOR "MINE AND QUARRY"

By D. J. O'Rourke.*

Much attention is paid to the mechanical details of drilling machines at the time of their purchase, to secure those which will be most efficient in the amount of power used and in cost for maintenance. Too often, this is as far as the user's interest goes. Having procured a good drill, he does not take steps to secure the very best working efficiency from it.

The question of drill steel, its selection, care, and use, is one which is given far too little attention, and which in many cases is the determining factor as to the economic success of a drilling plant. If the steels are of good materials, carefully made, sharpened and tempered for the work to be done, and if fresh steels are put into use as soon as the gauge begins to wear, the drills will come up to expectations as to speed and efficiency; but if the blacksmith is incompetent and the drill runner careless, the management could better afford to throw out its machines and go back to hand drilling.

THE BLACKSMITH.

The blacksmith's work should be recognized as almost equal in importance to that of the master mechanic at a drilling plant. The best smith is none too good, even if there should not be enough work to justify the wages he may demand. It is cheaper to have a blacksmith and helper idle once in a while than to have two or three drill runners and their helpers standing around watching the drills wearing themselves to pieces, and perhaps helping them along with a sledge hammer, while the drills fail to give results, merely because the bits are not right. There are also other men on the premises shoveling away dollars in the shape of coal, and this too must be taken into account. When it is all summed up, the idle time of the blacksmith and helper is an insignificant item.

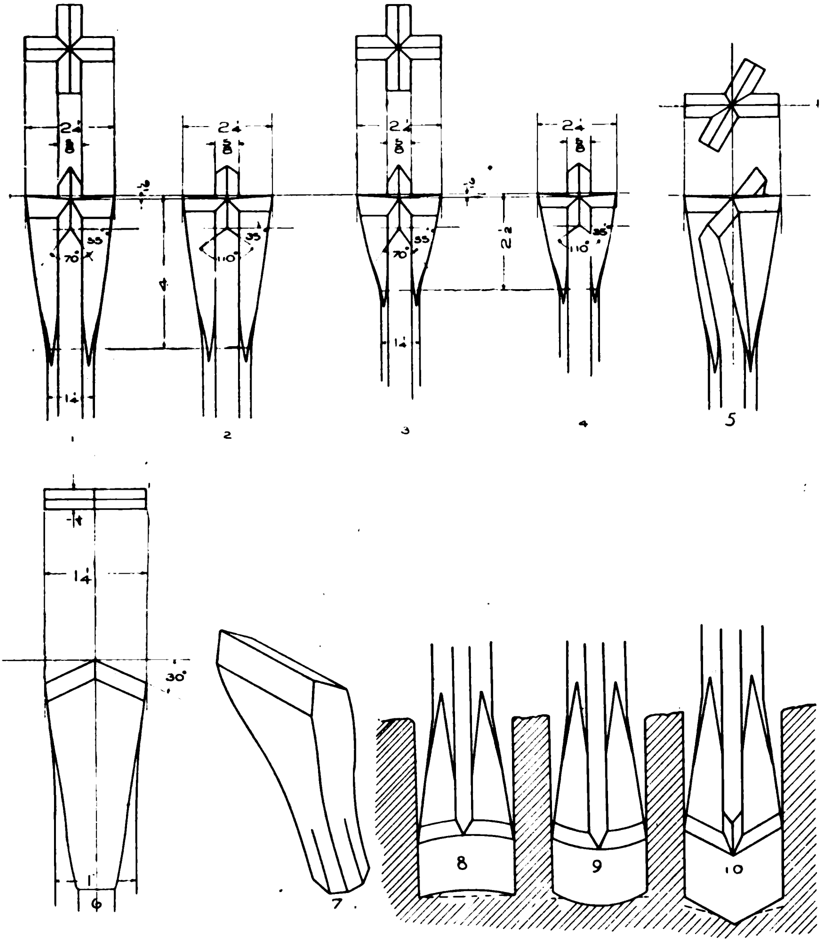
When a new compressor plant is installed, every feature, whereby a pound of coal or an extra foot of air may be saved or made is investigated, and every precaution taken to secure economical results. After the plant is running, the drilling, which was at all times the main object, is sometimes allowed to run along in such a way that anywhere from 10 to 50 per cent. of the power developed is completely lost. No one would think of allowing a hoisting engine to hoist a load with the brakes partially set, but something similar occurs when a rock-drill bit is run so long that it is the same gauge for an inch or more back of its cutting edge, or is allowed to be made with shoulders on it in the first place.

SHAPE OF THE BIT.

For drilling rock of any kind, the cross-bit, made like Figures 1, 2, 3, and 4, sometimes modified to the X shape shown in Figure 5, is usually employed. It will be observed that the bits above referred to are made concave with the corners of the wings ahead of the center. This design is recommended because used bits show very little wear at the center as compared with their outer edges. This indicates that the corners do the largest part of the work. The cutting done by them so weakens the rock toward the center of the hole that it does not afford so much resistance to the center of the bit.

Figures 8, 9, and 10 show what actually takes place in fracturing the rock with bits of several shapes. Figure 8 shows the concave bit, whose corners cut ahead of the center, making the line of breakage very weak and leaving little resistance for the center of the bit, as described above. Figure 9 illustrates a convex bit. In this, the center has to cut ahead of the corners. The fracture line is thus divided, leaving but little work for the corners to

*Claremont, N. H.



Shapes of Rock Drill Bits.

do. The cross shape of the center, together with the increased amount of work which falls upon it, in this case, greatly retards its cutting efficiency. Figure 10, the diamond-pointed bit, also divides the fracture line, but at the same time increases its length, leaving less cutting for the center. With this bit, the rock tends to break to a flatter angle than the angle of the bit, allowing the center to go in advance of the corners for a few blows, when the entire bit again comes in contact with the rock, fracture again takes place, and the process described above is repeated. This bit is recommended only for marble, soft limestone, and other even, soft rocks. Its advantage for this work lies in the fact that nearly all drilling in quarries is done on laid-out lines, so that this form enables the holes to be started accurately. The bit, however, is made very thin and is not strong enough to be satisfactory on general mining and contract work. The flat, or "bull" bit, as it is sometimes called, shown by Figure 7, is made in various shapes, but no matter how it is made its use is very severe on a rock drill. If

thin, it has no reaming qualities; if made heavy, as it generally is, the blow delivered imparts a severe jar to the machine. The flat bit, with diamond point, Figure 6, is a style which has been used in marble quarries from the earliest introduction of the rock drill. The steam pressure used in those days was considerably lower than now, so that this bit was satisfactory, and cut slow enough to ream the holes fairly well. Even under these conditions it was hard on the rotating device, but when higher pressures were introduced its cutting capacity was increased, while its reaming qualities remained the same. The flat bit may cut more rapidly for a short time, but in the long run the cross will be found more economical. The use of the X bit, Figure 5, is not general, but sometimes is desirable when a cross-bit will persist in drilling "rifled" or five-fluted holes on rock of some kinds. Sometimes rifling is charged to the machine, but the fact that the X bit is not required on all kinds of rock rather disproves this imputation.

SHARPENING THE BITS.

Figures 1 and 2 are bits for hard, non-gritty rock, and are alike except for the different angles shown on the cutting edges. Figure 1 shows about the highest angle to which the cutting edge can be made without danger of breaking. The angle shown on the cutting edge in Figure 2 is one of many which may be used under different conditions, without any other change in the bit. In cutting hard and medium hard rock, sharp drills and a wide-open throttle may be used to good advantage, and the hole will not ordinarily clog with mud, as the amount of rock loosened by each blow is so little that it is at once mixed into slush by the water in the hole. The sharp rebound of the drill when striking hard rock, together with the positive recovery of the machine, quickly gets rid of this slush. If the same bits and drill are run on an open throttle in soft or even medium soft ground, the hole soon becomes clogged. The reason for this is that while the hole remains of the same diameter, and the amount of water for mudding purposes is therefore the same, the steel chips out three or four times as much dust at each blow as it does in hard rock. The rate of cutting should therefore be reduced in order to keep the drill working at maximum efficiency. The speed may be regulated by throttling the air or steam, but this reduces the rapidity of action of the drill, so that it does not always mix into slush the dust caused at even the slower speed. The recoil of the steel from soft rock is also considerably less. In soft rock duller bits should be used, like that shown in Figure 4. The angle of the cutting edge may be even higher than this, sometimes almost square on the end, in order to secure good results.

LENGTH OF UP-SET.

In connection with the above subject, it is well to bear in mind the length of the wings or ribs for different kinds of work. Figures 1 and 2 show an extreme length for very hard rock, intended to give strength and hold the gauge as long as it is necessary. Figures 3 and 4 show shorter ribs which give the bit more clearance and make it more desirable for general purposes. Under ordinary conditions its ability to mix mud is much greater than that of the long bit like Figure 1. This shortness gives greater flare to the wings, causing a greater backward thrust to be given the cuttings, whether wet or dry. In rock which wears the gauge rapidly, however, the up-set should be longer. For drilling dry holes in tunnel headings or elsewhere the bit with short ribs has less tendency to allow the hole to draw up. The friction of this style of bit retards the machine but little, and will cause it to cut down toward the lower side of the hole, thereby straightening it. If this is done in time, it saves frequent drops of the arm and keeps the hole where it is wanted. It will be found on experiment that such

results cannot be gotten if a long bit with very slight clearance is used. The wings are five-eighths of an inch thick for the size shown in Figures 1 to 4, and should never be less than that for this size of bit and steel. They should be the same thickness throughout to allow free return of the cuttings. If gauge less than two and one-quarter inches is desired, make the bit correspondingly shorter.

GAUGE.

It should be especially noted that in all the sketches the outer edges of the wings are square. This feature is very important, to preserve the gauge of the hole. Whether the bits are sharpened by machine or by hand, care should be taken that no bits are made with the outside edges made rounding like a figure 8. The question of maintaining the gauge of the hole throughout its length is very important. It should be carefully determined just how much work each drill bit will do before the gauge begins to wear. In the hardest rocks a bit is never in condition to use the second time, and from 24 inches to 30 inches, depending on the length of the feed, is all that is ever attempted. Sufficient steel is therefore supplied, so that a sharp set is on hand for each hole. In softer rock and ore it frequently happens that the steel will not become dull even if used on several holes. Drill runners are, therefore, apt to disregard the question of the gauge so long as the cutting edge is sharp. The gauge, however, causes the rub in more than one sense. This is where the rub comes in that retards the work of the drills, shortens their life, consumes power, and increases the repair bills. For example, on this kind of rock a runner is given two sets of sharp steel to drill a required depth. Each set will drill perhaps two holes each without making trouble. About the third hole on which this steel is used the bits stick and there is a constant demand for a hammer or a chuck wrench with which to beat the steel, and if the right point of humor is reached there is no discrimination shown between the steel and drill piston. Here is a drill that worked all right on the first hole, fairly well on the second, and will not work at all on the third. The rock is the same and the drill is the same, but not so the bits. The only sharp bit that can be gotten into that hole must be made specially in the blacksmith shop half a mile away, so the hammering is kept up and the drill finally worked down somehow, taking usually more time than it took to put in the first two.

When the gauge wears so that a new steel is needed in order to insure its following the last, an entirely new set should be used. It makes no difference if one of the bits still appears good, for it is economical not to waste time with it. On any rock on which the cutting edges are not dulled upon the first hole, a system should be devised by the foreman or superintendent to determine how much each bit will do without too much "hammer help." The improvement will be very pronounced. The runner or blacksmith should have nothing to say as to this system. The blacksmith should have rigid instructions to furnish all bits to the exact gauge required, so that the new bits will work freely when placed in the hole. Much time is wasted from the fact that bits are not made exactly to gauge to begin with.

Users of mechanical drill sharpeners are advised to give thought and care to securing the proper dies and dollies to make bits suitable to the conditions under which they are to be used; also that when drills are being dollied the dies do not open. Some rather impossible-looking bits are occasionally seen for this reason alone.

TEMPER.

The matter of tempering bits is another point in which the blacksmith can save or waste much drilling time to his employers. A competent blacksmith will furnish bits of the precise temper, to suit the rock being drilled.

Duty on Diamond Drill Carbon.

The extensive use of Diamond Prospecting Core Drills in the United States renders of especial interest to the mining industry, a case now before the New York customs officials, for decision. Until about a year ago, black diamonds for diamond drilling and other commercial uses were admitted to this country, duty free, being classed as uncut stones for mining and industrial purposes.

The customs officials now in office at New York have decided, however, that while black diamonds in the natural or unbroken state, may be admitted free, stones split abroad are by this process, rendered more valuable and are therefore subject to duty. A tariff of 10 per cent *ad valorem* has, for the past twelve months, been in force on this class of carbon. This duty enables the carbon dealers to charge at least 10 per cent more for carbon than would otherwise be the case, thereby materially increasing the cost of diamond drill work to the consumer.

The Sullivan Machinery Company, which is the largest manufacturer of Diamond Drills, and also a large operator of these machines, for contract drilling, is one of the heaviest buyers of carbon from dealers in New York, London and Paris. It demands stones of the highest grade, not only for its individual use, but for that of its customers, many of whom prefer to trust to its knowledge and experience in the selection of stones, rather than to buy direct from dealers. This company, in the interest of all users of diamond drills, as well as in its own, has recently registered a protest against this tariff. A test case, involving the payment of duty on a parcel of broken stones from England, was brought before the appraiser in New York City about ten weeks ago. The plaintiff demonstrated that black diamonds were a natural product, not found or produced in the United States, but only discovered in a certain part of Brazil, consequently that the tariff could not be justified on the ground of protecting an American industry; also that unbroken stones were of no value whatever for drilling until reduced by splitting to suitable sizes; and that for this reason, broken stones were no more valuable than unsplit carbon of proper size for immediate use, which are now, and always have been, admitted free. It was also shown that original parcels, containing both natural and broken diamonds are sold in Europe to American importers at a flat price, whether they are suitable for use with or without splitting.

The customs officials endeavored to show, by the evidence of New York carbon dealers, that broken stones command a higher price in this country than the natural variety, but no specific instances were brought out in which split stones had been sold or quoted at a higher price than natural stones of the same weight and quality. On the other hand, letters from these New York dealers were placed in evidence by the plaintiff, in which the same quotation had been made on both classes of carbon shipped mixed together in the same parcel.

The plaintiff made a strong point of the fact that the tariff was of no value to any concern or industry in the United States, but was rather a burden and a restriction upon the entire mining industry. Mexico and Canada have always admitted carbon free, under the name of "Miner's Diamonds" and in the case of Canada, Diamond Drills are ad mitted free, the Government holding that they perform a valuable office in the development of the mineral resources of that country, while nearly every other class of mining machinery manufactured in the United States is assessed 27½ per cent. *ad valorem* for entry into Canada.

The test case above referred to, is now under consideration by the Board of Appraisers and it is hoped that their decision, which is expected shortly, will result in revoking the duty on black diamonds.

Powerhouse, camp, and western approach to the new tunnel.

THE SECOND RATON HILL TUNNEL OF THE ATCHISON, TOPEKA & SANTA FE RAILWAY.

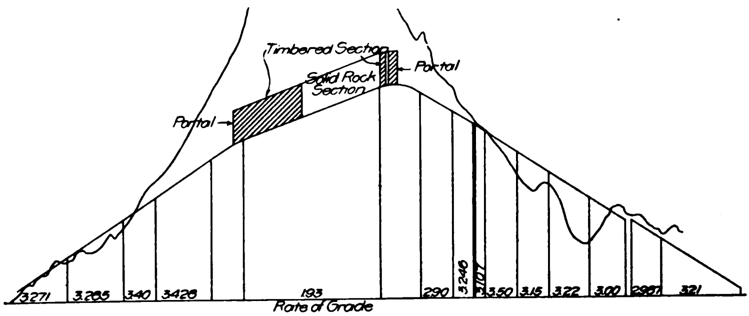
WRITTEN FOR "MINE AND QUARRY" BY W. P. J. DINSMOOR.*

The highest point on the main line of the Atchison, Topeka & Santa Fe Ry. is at Raton Pass, on the state line between Colorado and New Mexico, where an elevation of 7,608 feet above the sea level is reached. The steep grades required to ascend to the pass from both sides present a very great handicap in hauling the tremendous volume of through traffic that is carried over this railroad. Trinidad, Colo., is only 15 miles by the railroad from Raton Pass, but the difference in elevation between the two is about 1,600 feet, the tracks rising on a practically uninterrupted grade between the two points. The first ten miles of this ascent is less abrupt than the remainder, as a grade of 184 feet to the mile is maintained in the last five miles. The rise required to reach the pass from the west is about seven miles long and involves an ascent of 991 feet, although steep grades occur for some 10 miles farther.

When the line was first built through Raton Pass it crossed the latter on a switchback. This was replaced about 30 years ago, by the present tunnel, which is 2037.5 feet long, with its west portal at the summit of the grade. This is a single track tunnel, although the tracks both east and westward from the pass are double.

The congestion of main line traffic on the grade, arising from this fact, caused the railway company to undertake the construction of a second single track tunnel in February, 1907. This tunnel will be opened to traffic in the course of a few weeks, and will be used exclusively for west-bound trains. There were two important reasons for driving a new single track tunnel rather than enlarging the

* Denver, Colo.



Profile of old tunnel and track on either side.

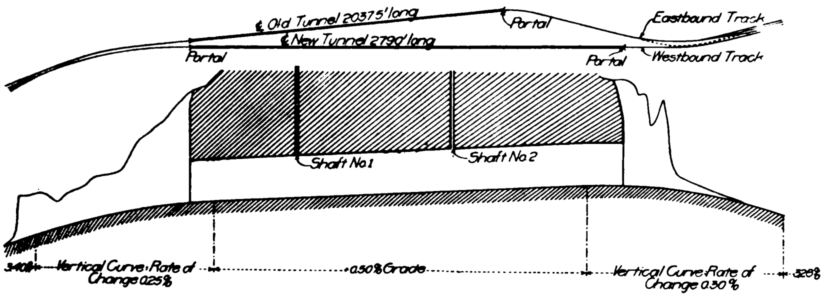
old one. First, traffic can be maintained at all times without interruption while the new tunnel is building. Second, the new tunnel is so located that the grade through it will be only 0.5 per cent, instead of 1.93 per cent, as in the old tunnel. This will permit west bound trains to cut off their helper engines, of which from one to three are needed, before entering the tunnel, instead of requiring their assistance through to the west portal, as at present. The sketches show the plan and profiles of the two tunnels.

PHYSICAL DETAILS.

The new tunnel will be 2,790 feet in length from portal to portal. The two tunnels are close together, their east portals starting at the same point. At these portals their center lines are 40 feet apart. Both tunnels are on tangent for their entire length, their center lines making an angle of about 5½ degrees, so at the west portal of the old tunnel they are 238 feet apart, although the west portal of the new tunnel is 752.5 feet beyond that point. The present track curves around the hill at the west end of the old tunnel and 800 feet beyond the west portal of the new tunnel joins the track that will be laid through the latter.

The new tunnel is to have a cross-section of unusual size, as may be seen from one of the accompanying illustrations, page 228A, and is to be lined from portal to portal with concrete. Above a point slightly below the spring line of the arch, the material encountered is a close-grained hard sandstone. Below this point is a three-foot vein of soft coal underlain by coal shales. The old tunnel is through practically the same material and is only timbered for about half of its length, part of the timbering being at each end. Experience with falls in the unlined solid-rock section of this tunnel, however, has led to the decision to line the new tunnel throughout. The clear height inside the lining will be 24 feet above the top of the rail, at the center line of the arch, and the clear width at the springing line of the arch, 17 feet.

In driving the new tunnel through soft material the excavation is made to a minimum width of 22 feet and a minimum height of 29 feet at the center line. In such material the side walls of the concrete lining have a footing course three feet wide and 1.5 feet high, the rear of which is flush with the rear face of the wall. The latter varies in thickness from 2.5 feet at the base to two feet at the springing line of the arch, the rear face being vertical and the front face battered six inches in 16.5 feet. The arch ring also has a thickness of two feet. Where loose material and rock are encountered the tunnel is driven to a minimum width of 21 feet and a clear height of 28.5 feet at the center line. The side walls of the lining in such material have a 1.5x2.5 feet footing course, are two feet thick at



Plan of both tunnels and profile of new tunnel.

the base and 1.5 feet thick at the springing line of the arch; the ring of the latter is 1.5 feet thick. These various dimensions of the concrete lining are for minimum sections. The irregularities between the excavation and the outside limits of the concrete are filled with loose stone packing, laid by hand.

Very little water was encountered in driving the tunnel, so no special provisions had to be made to carry away the seepage.

Such inflow as does occur, however, will be taken to the east portal by a gutter formed in the top of the footing courses of the walls. Refuge bays for watchmen and trackmen working in the tunnel are provided at intervals of 232 feet. These bays are to be placed alternately on both sides of the tunnel. They are simply arched openings five feet wide and 7.5 feet high at the center, in the side walls. Three larger openings for placing small push cars are to be built in the side walls. These openings are eight feet wide and 12 feet high at the center, and are spaced 696.5 feet apart.

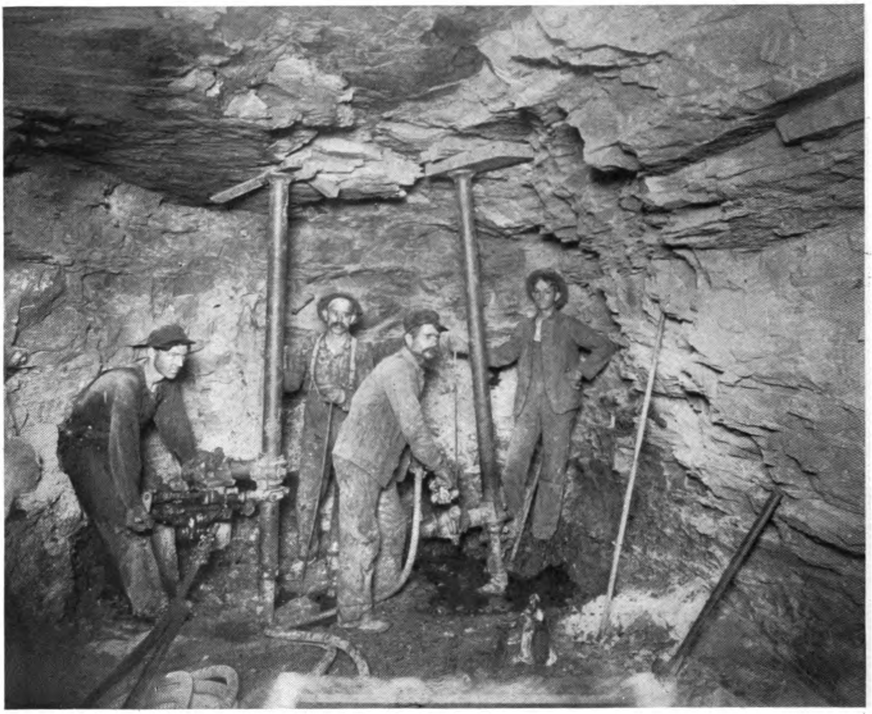
CONSTRUCTION.

In constructing this tunnel the customary method was employed of driving a heading and then removing the bench. Two construction shafts, five feet, eight inches by ten feet, were sunk to expedite the work, one 1100 feet from the west portal, 130 feet deep, the other 700 feet from the east portal, 125 feet deep. This gave six headings, which were driven at the same time. Steam for both the hoisting engines was supplied by a 100 H. P. boiler set up between the two. The material removed from the headings carried forward from the shafts was hoisted to the surface in 1½ yard dump cars and wasted in adjacent spoil banks.

An approach cut containing about 40,000 cubic yards had to be made at the east portal, and one of 20,000 cubic yards at the west portal. The east cut was made partially in earth and partially in rock and was taken out by hand, the material being hauled away in dump cars. The west cut was largely in rock and was made with a steam shovel.

Three shifts were employed, working eight hours each, and the plan of operation consisted in drilling and shooting a round of holes and loading out the muck resulting from the previous shots, every shift. In hard rock, Sullivan "UF-2" 3¼ inch drills on columns were used to do the drilling, but in the coal formation, rotary coal augers were successfully employed.

After the heading had been broken through between the west shaft and the west portal, work was begun upon the bench. The soft material above described was loosened by a few shots from deep drill holes, fired while the rock was still covered with muck from the previous blast. This protected the steam shovel, used for loading out the muck, from damage.



Sullivan "UF-2" Drills in the heading of the second Raton tunnel.

The steam shovel took out 1300 linear feet, involving over 18000 cubic yards of material, in three months. It was then moved to the east portal and started on the bench at that end. Meanwhile the bench adjacent to the west construction shaft, starting at the point where the shovel had been taken out, was removed and loaded into cars by hand, which were taken up the shaft to be dumped. The west 1,100 feet of the tunnel was thus prepared for the concrete lining, work on which was carried on without interference from the unfinished portion of the tunnel excavation.

POWER EQUIPMENT.

The main camp and the main power plant are at the west portal. In the power house are two 80-horse-power tubular boilers, driving a Sullivan Class "WB-2" simple steam and two-stage air straight line air compressor, with a capacity for supplying 12 3¼-inch rock drills; also a 90-horse-power high speed engine belted to two 25-KW, 125 volt generators. These generators furnish current for the electric lights used in the tunnel and shaft and for the ventilating fans, of which there are one at the east portal and one at the east shaft.

The compressor furnishes air to the drills (eight Sullivan 3¼-inch and 22 rotary augers), also to the steam shovel, pumps and blacksmith's forges. The air is distributed by a four-inch air line 3,200 feet long, from the 4½x12 foot receiver at the plant, over the hill through which the tunnel was driven, to the east one of the two shafts, and thence continued as a 2½-inch line to the east portal. A two inch branch was taken from this four-inch line at both of the shafts and carried

down the latter to the face of the excavation on the headings; connections were also carried to the working face of the headings driven from the portals.

The dump cars were handled by two contractor's steam locomotives, fired with coke to prevent excessive smoke in the tunnel. A concrete mixing plant is set up on one side of the west portal approach cut, where rock can be obtained readily for the concrete. A rock crusher is installed just above the mixing plant and delivers to a storage bin over the latter. The concrete is made in a ¾ yard mixer, set on a tower built over the service tracks leading into the tunnel so that concrete can be dumped directly into cars on those tracks. The equipment used in placing the concrete in the tunnel lining forms, consists of a working platform mounted on cars.

PROGRESS.

Work on the tunnel has been carried ahead very rapidly in spite of numerous handicaps. The construction camp was established March 22nd, 1907; work was started on the construction shafts April 10th and completed may 15th; the west portal heading was started May 10th and the other five on May 25th, but owing to the scarcity of labor only the portal headings were carried on continuously. The first two headings met July 10th, the second two August 6th, and the last two September 9th. The removal of the bench was finished about January 1st, of this year. The concrete lining was recently completed, and the tunnel will be ready for use in a short time.

RECONSTRUCTION OF OLD TUNNEL.

After the new tunnel has been finished so traffic can be diverted through it, the old tunnel will very probably be enlarged to the same section as the new one and lined from portal to portal with concrete.

The plans for the new tunnel were prepared under the direction of Mr. C. A. Morse, chief engineer of the Atchison, Topeka & Santa Fe Ry., and the construction work is being prosecuted under his supervision by the C. J. Lantry Construction Co., of Kansas City. Mr. Jos. Weidel is engineer in charge of the construction work for the railroad company, and Messrs. C. E. Higbee, Theodore Vos Burgh and T. M. Broderick, for the contractor.

Acknowledgement is tendered to the *Engineering Record* for some of the illustrations and for a portion of the details given in this article.

Heading and timbering in new tunnel.

MINE AND QUARRY

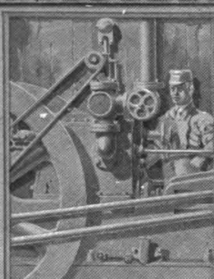
Vol. III. No. 2. OCTOBER, 1908

GANTT'S QUARRY, ALABAMA

A DEPARTURE IN MINE POWER PLANTS

ALABAMA MARBLE

PROGRESS ON THE ASHOKAN DAM



PUBLISHED BY THE SULLIVAN MACHINERY CO. RAILWAY EXCHANGE BUILDING, CHICAGO.

Rogers & Company

TABLE OF CONTENTS

PAGE

Editorial - - - - - - - - - 229

A New Departure in Mine Power Plants - - - 230
G. M. CRAWFORD

Testing for Bridge Foundations - - - - - 240
F. H. BAINBRIDGE

Machine Coal-Mining in Illinois - - - - - 245

Alabama Marble (Contributed) - - - - - 246

Progress on the Ashokan Dam - - - - - 251
JOSEPH H. BROWN, Jr.

A New Coal-Mining Machine for Low Veins - - 255

MINE AND QUARRY

Vol. III. No. 2. OCTOBER, 1908

A Bulletin of News for Superintendents, Managers, Engineers and Contractors.

Published by the Advertising Department of the Sullivan Machinery Company.

Address all Communications to MINE AND QUARRY, Railway Exchange, Chicago. Sent to any address upon request.

Readers are requested to notify MINE AND QUARRY of any correction or change in address.

AN unusual but very practical and economical application of electricity to the operation of coal-mining machines, which might also be profitably adopted for driving rock drills and stone channelers, is exemplified in the power plant at Yatesboro, Pa., described in this issue. The electric power, generated in the cheapest possible manner, is carried to local distributing centers, where it is converted into air power, all with the least percentage of loss known to modern practice. This air is led to standard pick machines through short pipe lines, supplying the machines with power at undiminished pressure. By this plan the power is produced under conditions of the highest economy and convenience, and there is no cumbrous or complicated apparatus at the working face. The rapid progress and the convenience of operation secured by the standard air-driven machines are more important factors in the efficiency of mining work than the actual horsepower consumed per machine, without relation to the results gained. Direct or semi-direct electric drive is perhaps economical of power, but its use is attended by slower progress and higher expense for repairs, so that the cost per foot of advance is much larger than if air had been used, in the ordinary way.

MINE AND QUARRY is a medium for the description of new machines, new processes, and of applications of machinery, which will interest the engineers, managers, and mechanical men of ore and coal mines, quarries, and contracting enterprises. No charge is made for the paper, but a card is enclosed in each issue, so that readers may acknowledge it, and correct errors in their address. The circulation is a large one. The publishers have no desire to send the paper where it is not read and to individuals not interested in the topics presented.

If you wish to receive MINE AND QUARRY in future, please return the card. If not, write "discontinue" on it with your name and address, and mail it to us, in order that the cancellation may be made on our lists.

ATTENTION is directed to the use of stone-channeling machines, described in this issue, for the sole purpose of avoiding the jarring and loosening effect of blasting upon rock walls. In this instance it is important to prevent shattering of the strata in order to minimize leakage beneath a great dam. In other cases, the use of channelers permits excavation lines to be run close to the foundations of buildings and other structures, without danger to them, as in the case of the New York Central sub-grade terminal yards in New York City. In still others, channeling obviates rock slides, which might be caused if the wall were blasted, and makes retaining walls unnecessary. This is one reason why 24 Sullivan Channelers were purchased for the Panama Canal.

A NEW DEPARTURE IN MINE POWER PLANTS.

THE INSTALLATION OF THE COWANSHANNOCK COAL AND COKE CO. AT YATESBORO, PA.

*BY GEO. M. CRAWFORD.

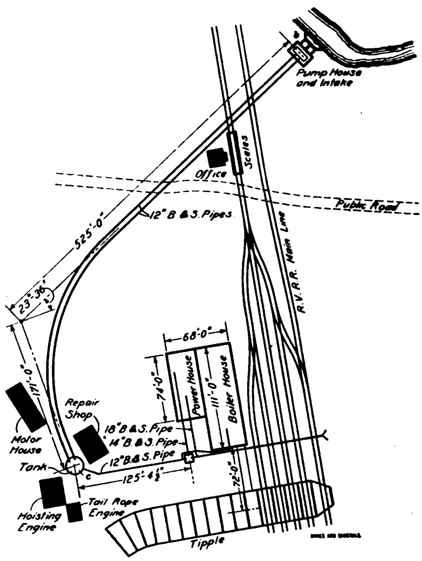
The extension of mining operations over a considerable area of ground is now common in both coal and ore mines. In such instances the generation and transmission of air and electric power assumes new and interesting aspects. The power, which is used for mining machines, pumps, drills, hoisting and haulage, ventilation, etc., may be produced: (1) in several independent plants, each with boilers, generators, and steam- or belt-driven compressors; (2) in a central station, with large economical steam units, the air being piped and the current wired direct to the machines; (3) in a central electric generating plant, from which current is wired to substations, where the air compressors and motors which drive the machinery in each part of the field are located.

The first plan is now seldom adopted, owing to the high cost of supplying fuel and water to each of several plants, and of the duplication of attendants. Further, the system lacks economy and flexibility, because, as the workings are extended, the power lines become longer, more expensive to maintain, and reduce the efficiency of the whole plant. Such a plant can be moved to a new location only at heavy expense for buildings, new machinery, and facilities for transporting supplies.

The second plan is much more convenient and economical in the production of power, but is wasteful in transmission. It requires long air lines of large size and electric wires of large diameter to carry low voltage current suitable for machine operation.

The last plan represents the latest practice, which has been adapted to mining operations from the field of power production for industrial purposes. It involves the production, in a central plant, of high voltage current by steam or hydraulic turbo-generators. This current is then carried to substations, where it operates air compressors, fans, pumps, and haulage locomotives. This results in the greatest possible economy of pipe lines, wiring, attendance, buildings, and supplies. When the workings are extended to the point of "diminishing returns," a new substation may be installed, or the old one moved, at but small expense, and the piping and wires may be used over and over.

Applications of this plan or principle are as yet few in the mining field, and particularly so in that of coal-mining, in which the importance of economy in power production is too often overlooked.



Plan of Yatesboro power plant.
(*Courtesy of Mines and Minerals.*)

*Pittsburg, Pa.

For this reason the following description of such a power plant will interest mine managers.

The mines of the Cowanshannock Coal and Coke Co., at Yatesboro, Armstrong County, Pa., are midway between Dayton and Kittanning, 24 miles west of Punxsutawney. Shipping facilities are provided by the Rural Valley Railroad, a branch, six miles long, of the Buffalo, Rochester & Pittsburg, with which it connects at Echo. The natural advantages of this location are ideal for mining purposes. The company owns about 19,000 acres of coal land, covering an area about four by nine miles in extent. The coal mined is the Freeport seam, averaging four to 4½ feet in thickness. It is used for both steam and domestic purposes. Being of a strong texture, it is hard to undermine; but when shot, holds together well, so that the proportion of slack is low.

The mines have been worked for about eight years, during which some 1,000 acres of coal have been mined. At this rate, it will be several generations before the property is exhausted, so that a first expense in power-plant installation has abundant time to prove its economy.

METHOD OF OPERATION.

There are now two sets of openings on the property. In both cases the coal is mined from the outcrop on the double-entry system. The main entries run parallel on a slope of from three to five per cent. with 60-foot centers. One is used as the main haulage way, and the other as a main traveling way to the workings. A third entry, parallel to and 60 feet from the others, forms the air course.

Right- and left-hand entries are run at right angles to the slope entries at intervals of 1,000 feet. The cross entries driven from the former are 500 feet apart. Rooms are turned from the coss entries with 50-foot centers, the pillars being 18 feet wide. All entries, room necks, and

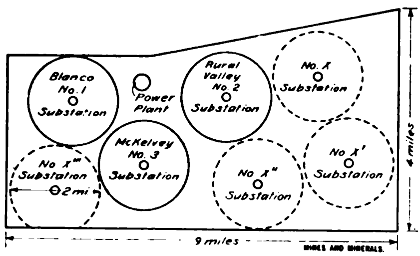
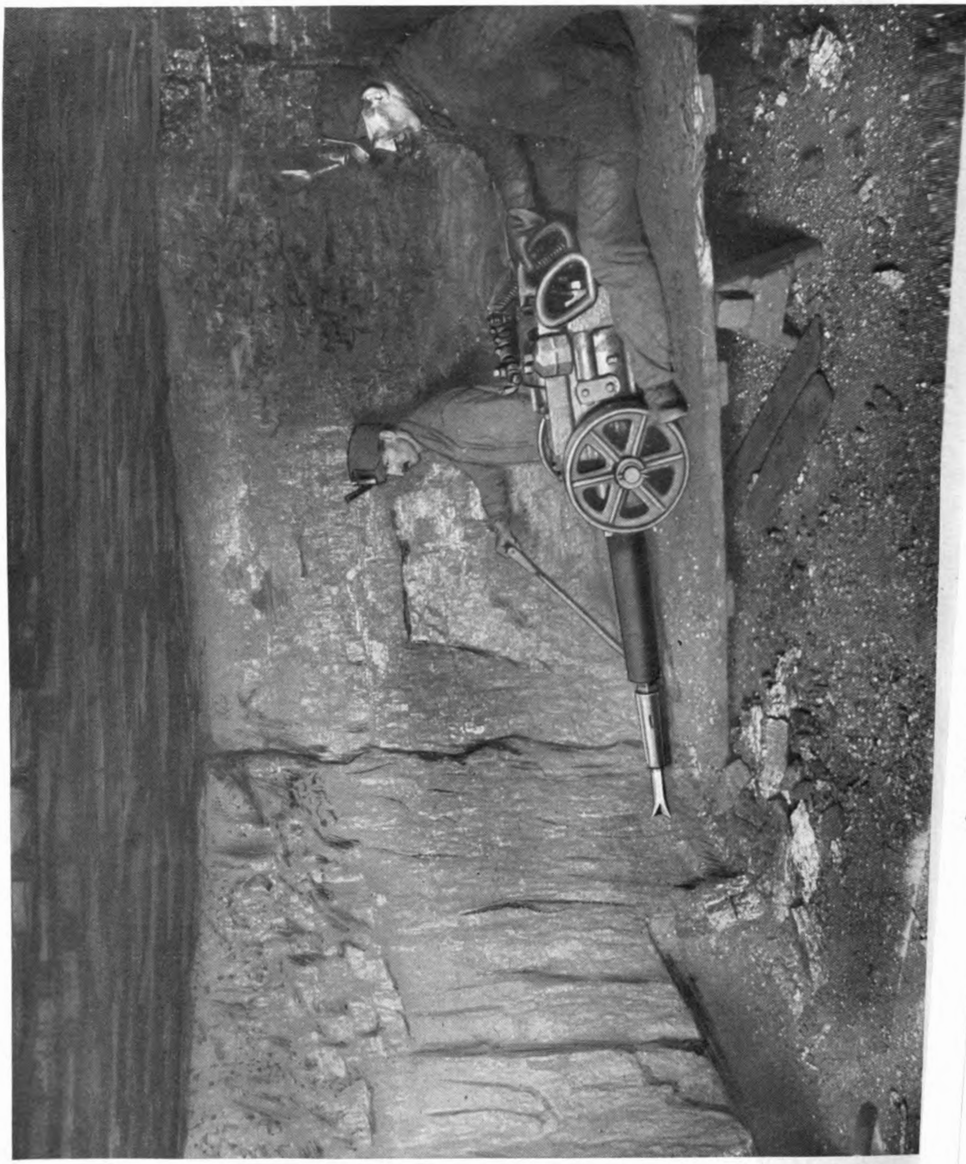


Diagram showing arrangement of substations
(Courtesy of Mines and Minerals.)

break throughs or air courses are 12 feet wide. Fifty feet of coal is left on each side of the entries for support. There is a fair slate top above the coal, and strong fire-clay below. The entries are driven 5½ feet high, the top or bottom being removed, as conditions require, to secure proper height. They are laid with 35-pound iron T-rails, while the rooms are equipped with 12 pound iron T-rails, laid on the bottom, without any lifting to increase the height.

MACHINE MINING.

The mines work six days a week, two eight-hour shifts, and produce about 3,500 tons of all grades per day. The coal is mined exclusively with Sullivan Compressed-Air Pick Machines of the Class "5" type. This machine, of which 92 are in use, has a cylinder 5⅛ inches in diameter, cuts to a depth of 5½ feet, and weighs 825 pounds. The company adopted this make and class of pick machine after an experience of several years with the various machines upon the market, which satisfied its officials as to the superiority of the Sullivan machine, for its conditions in regard to cutting capacity, economy of power and maintenance, and convenience in operation. The Jefferson and Clearfield Coal and Iron Co. and the Rochester and Pittsburg Coal and Iron Co., which are controlled by the same interests as the Cowanshannock Coal and Coke Co., also use Sullivan "Punchers" extensively, owning about



One of 90 Sullivan

225 machines. One of these machines is shown in operation in No. 1 mine at Yatesboro, on page 232.

After the coal is undermined, three holes are drilled in the face to receive one-inch powder. The charge is six to eight inches long. The center is shot first, and after this "tight" shot the two sides or "loose" shots; the latter breaking down the coal which hangs to the rib after the center has been freed.

HAULAGE.

The undermined coal is loaded into cars at the face. The cars are pushed by hand to the cross entries, where they are gathered by six- and eight-ton electric locomotives, hauled to partings or side tracks in the main entries, and thence pulled in large trips to the tipple by 10- and 13-ton electric locomotives. Seventeen locomotives of different sizes are employed in all.

TIPPLES.

There is a tipple for each set of openings, that for No. 1 mine being shown on this page. Each tipple is equipped with two automatic cross-over dumps. The coal is loaded into railroad cars on one main track and four sidings, so arranged as to permit loading six sizes of coal—viz., run of mine, lump, slack lump, nut, slack, and special mine run. The cars, on being loaded, are run to the railroad scale office, 300 feet below the tipple, weighed, and made up in trains on three 1,300-foot side tracks adjacent to the main line.

VENTILATION.

The mines are ventilated by three large steel-plate fans; one is located near each of the tipples, and the third near the No. 1 power substation, as described later.

LABOR.

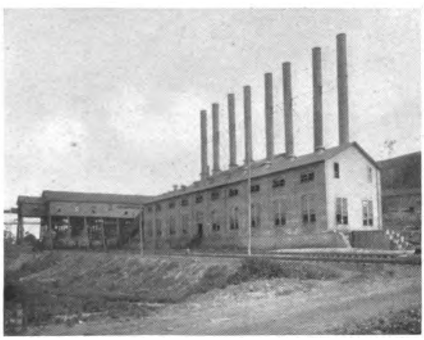
The company employs about 1,000 miners underground, who are paid on a tonnage basis. The men live in 225 company houses near the mines.

THE NEW POWER SYSTEM.

During the first six years of operation the power plant consisted of two units, one at each set of openings. These contained tubular boilers, straight-line air compressors for the mining machines and pumps, and electric generators, delivering current at 500 volts, for haulage.

It became apparent, as the mines developed, that several more of these plants would be needed, at widely separated points, to obviate losses in transmission. The high cost of providing fuel and water to these plants made this plan objectionable.

After much deliberation, the company's engineers decided on a plan hitherto not attempted in coal-mine practice—viz., a central power plant, with substations in different parts of the field. This plan involved large expense, and for that reason could be considered only by a company like this, of great financial strength. The plant was to be centrally located, at a point convenient for fuel and water, and was to represent the highest economy in operation. Electrical power was to be distributed at high voltages to the different substations, and then stepped down to proper intensities for haulage, pumping, and the other requirements of operation.



Central power plant and tipple of No. 1 Mine at Yatesboro.

Boiler-room, showing Underfeed Stokers and Chutes from coal-storage bin.

This plant was completed about two years ago. It is shown on page 233, while the diagram on page 230 shows its general arrangement and dimensions.

BOILER-ROOM.

The boiler-house, 111 by 37 feet, is shown on page 233. It contains four batteries of water-tube boilers, each consisting of two 500-horsepower units, making a total installation of 4,000 horsepower. The plant is so arranged as to permit an increase to 6,000 horsepower when necessary.

The coal supply (slack) is carried from a 15-ton hopper under the tipple to a steel bin in the boiler-room on a rubber belt conveyor. The bin and conveyor run the full length of the building, and an automatic reversing tripper, running above the bin, distributes the coal evenly. From this bin, which holds 300 tons, the coal passes through spouts with controlling gates to the hoppers on the underfeed stokers. The stokers are run by steam, with automatic devices for controlling the air pressure and quantity of coal delivered to the grates. These appliances hold the steam pressure uniform at about 175 pounds. Ashes are removed in standard railroad cars through a tunnel, running the length of the building, under the concrete ash-pits below the boiler-room floor. The tunnel entrance is shown in the photograph on page 233.

A 12½-foot blower supplies draught to the furnaces. This fan is driven by either one of two horizontal steam engines, one of which is usually held in reserve.

Duplex steam feed pumps, 14 x 8 x 18 inches, also installed in duplicate, furnish

water, which is first heated to 205 degrees by an open-type feed-water heater. This takes its supply from the condenser discharge, exhaust steam from the auxiliaries being used for heating the water. The water supply for the condenser is pumped from a nearby creek by centrifugal pumps at the rate of 6,000 gallons per minute.

It may be seen from the cut on page 233, taken while the plant was in full operation, that this system secures the whole fuel value from the coal. No smoke came from the stacks during the exposure of the plate.

These boilers supply steam for a haulage engine, hoisting engine, and pumps, used for the town water supply, as well as for the turbo-generators.

ENGINE-ROOM

The cut below shows the engine-room, 74 x 31 feet, from the balcony. The main plant consists of two 1,500-KW. turbo-generators, which use saturated steam at 170 pounds pressure, with 26 inches vacuum. They revolve 900 times per minute, and are run night and day, seven days a week, under an average load of 2,500 KW. Sixty-cycle, three-phase, alterating current is generated at 6,600 volts. Each turbine is fitted with a separate jet condenser, located on the first floor. Their tops, connecting with the turbines, may be seen in the cut, at about the floor line of the balcony.

Provision is made for adding two more generating sets when needed. Exciting current for the turbos is supplied by a 75-KW. turbo-generator and by a motor generating set using alternating current at 220 volts. A 300-KW. motor generator set in the basement of the powerhouse supplies current for haulage in and about the tipple.

A traveling crane in the engine-room provides handling facilities for the heavy machinery. The machinery in the blacksmith, machine, and carpenter shops, which form a part of the main power plant, are driven by electricity.

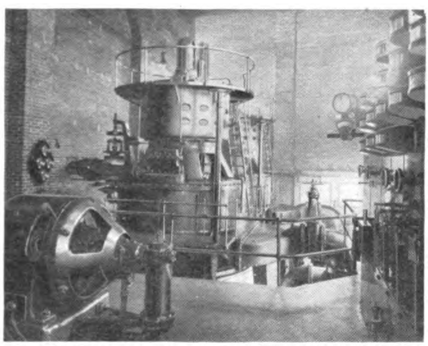
SUBSTATIONS.

The sketch, page 231, shows the general shape of the company's property. The three solid circles show the three substations already installed and the area served by them, while the dotted circles show locations for future stations, as the development advances. Blanco station, or No. 1, is 8,000 feet south of the power plant; McKelvey, or No. 3, is 10,000 feet to the northeast; and Rural Valley, No. 2, is 12,000 feet northwest.

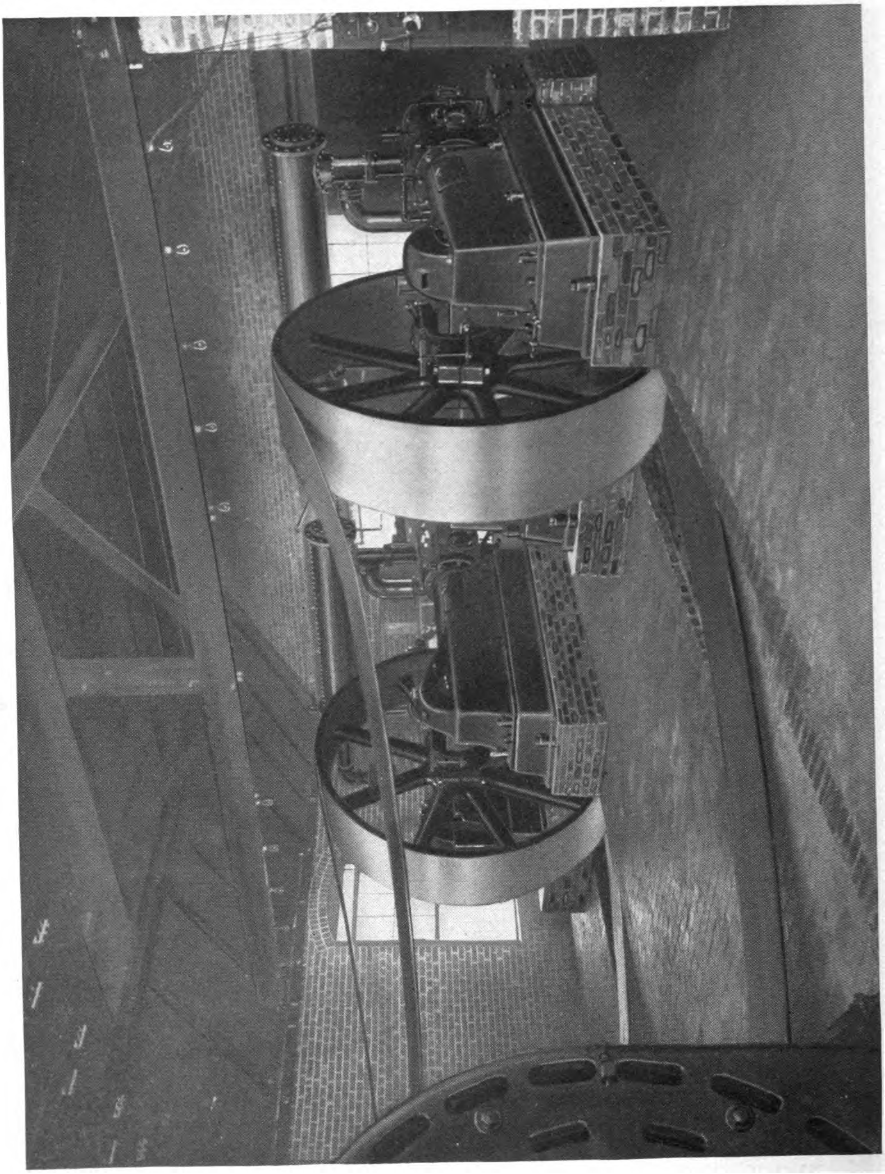
The current is stepped down by transformers at the substations, and delivered to the haulage systems by rotary converters at 500 volts direct current.

The air compressors for operating coal cutters, pumps, etc., are belted to motors taking alternating current at 6,000 volts. These high-voltage motors were the first of their kind used in this country, and their successful operation shows what can be done without stepping down and converting the current, as is ordinarily thought necessary.

The Blanco station contains one 300-KW. rotary converter and step-down transformers, furnishing direct current at 500 volts for haulage. Three 1,400-foot duplex, belt-driven air compressors



Turbo-Generators in the Central Powerhouse



Sullivan "WJ" Air Compressors in the Rural Valley Station, Cowanshannock Coal and Coke Co., Yatesboro, Pa.

are driven each by a 250-horsepower motor as above described. There is also a 400-horsepower variable speed induction motor of the same type, direct connected by a flexible coupling to a 12½-foot steel fan, which runs at from 90 to 286 revolutions, and at full speed supplies 400,000 cubic feet of air against a 5½ inch water-gauge.

The air piping and wiring from the Blanco station enters the mine through a slope driven to the outcrop.

The McKelvey station contains three air compressors of the same capacity as at Blanco, but there are no converters or transformers, as power for haulage is not furnished from this point. The air mains enter the mines through the slope, as at the Blanco station.

The No. 2, or Rural Valley station contains a converter and transformer, as at No. 1, also four air compressors, driven by 250-horsepower, 6,000-volt, 60-cycle, three-phase, alternating current motors.

SULLIVAN AIR COMPRESSORS.

The photograph on page 236 shows two of these compressors, of the Sullivan Class "WJ," duplex, two-stage type. The low-pressure cylinders of these machines are 24 inches and the high-pressure cylinders 14½ inches in diameter, with a common stroke of 18 inches. They furnish 1,414 cubic feet of free air per minute at 150 R. P. M.

In the design of these machines pains is taken to secure the best possible efficiency. The cylinder bodies and heads are water-jacketed, and the air-intake passages are so arranged as to keep the water jacket between the incoming air and the cylinder wall up to the point of entrance to the cylinder. The intercooler is of unusual area, and the air is forced to take a circuitous passage across the cold tubes in its way from one cylinder to the other. Moisture carried by the air through the first stage of compression is practically all condensed and removed in this cooler.

The inlet valves are of the semi-rotary pattern, driven by eccentrics on the shaft. This valve motion and the large diameter of the valves give a very free opening for the air, and quick closing, which insures a full cylinder at each stroke. The valves are so set that air pressure from the cylinder holds them to their seats, minimizing leakage. Automatic poppet discharge valves with removable seats render inspection and care easy. The sectional view of the cylinder, page 238, shows the above arrangement.

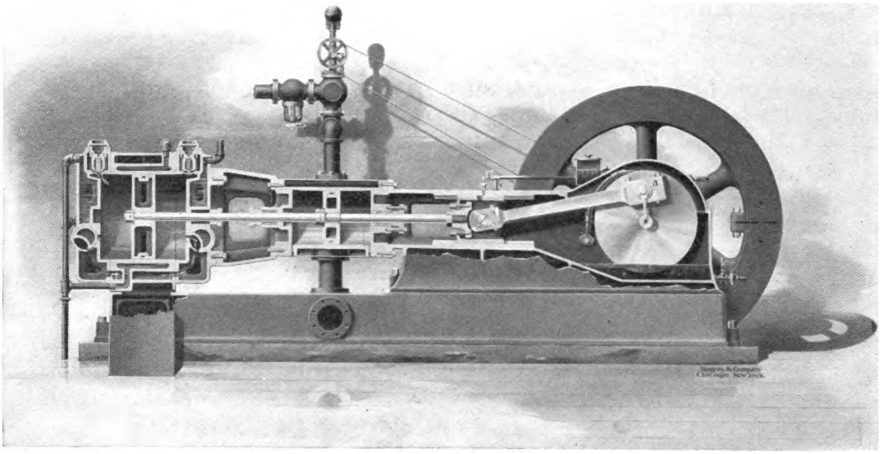
The eccentrics, piston rods, and connecting rods are enclosed in a dust-proof case, and these parts are automatically oiled from tanks in each frame, into which the lower edges of the crank disks dip. These machines are practically automatic. The frames are of the "heavy duty" type, and the whole machine is supported on an iron base to insure correct alignment.

These compressors were constructed especially for this work. As it is contemplated that the substations will be moved from time to time, the base of each machine is cut through the center and bolted together. When the machine is knocked down, any part of it may be hauled by wagon. When being reset, perfect alignment of all parts is provided for by means of dowels.

BORE-HOLES.

At the Rural Valley substation the air and electric lines are taken into the mine by means of three bore-holes, one for each form of power, sunk with a churn drill to the heading, close to the rib.

The holes are 10 inches in diameter. The one for air is cased to bed-rock; inside of the casing runs the eight-inch air main. The space between the pipe and the casing is filled solid with cement from top to bottom, holding the line rigid and protecting it from acid waters. The main runs along the slope entry, and from this



Sectional view of a Sullivan Duplex Self-Oiling Air Compressor (steam-driven). The Air Cylinders, Frame, and Oil Wells on the machines here described are of this type.

the branch pipes are carried to the rooms, where the machines are supplied by 1¼-inch lines.

This system constitutes a large saving in pipe as well as in power economy. As a section of the mine is worked out the pipe is lifted and relaid elsewhere. The short length of the lines permits practically the full capacity of the compressors to be delivered at receiver pressure at the machines, thus securing the best efficiency. Air is also used in all pumps which deliver water to sumps. Electric rotary pumps raise the water from these sumps to the surface.

The two bore-holes for electric wires are cased to the coal and cemented, like the air line. The air and one of the electric bore-holes are sunk close to the substation, as shown on page 239. The second hole for wires is some distance away, as it is considered safer and more convenient to handle the main power cable on the surface.

At the Rural Valley station a bore-hole 300 feet deep has also been sunk close to the rib, reaching some distance below the seam. This well supplies cooling water for the compressors, by means of an air lift, to the tank shown in the view of this station on page 239.

The main water supply is from a creek near by, but the well is used during the summer, when the water in the creek is low.

ADVANTAGES GAINED.

The installation of this central plant enabled the company to discard 10,000 feet of eight-inch pipe line, together with many hundreds feet of smaller pipe, which are being lifted from time to time, as conditions permit. The advantages of this plan of installation are easily seen. The high voltage permits but small losses in transmission; the generation of power so close to the machines minimizes the loss of efficiency; and the mobility of the entire plant prevents waste of capital and labor in extending the development of the property.

ATTENDANTS.

While this plant is more than double the capacity of the former ones, only 13 men per 24 hours are required for the care of the main power-house and substations. Twenty-four men per 24 hours

were needed to look after the two original plants. At present the day force is as follows: Boiler-room, two men; engine-room, one man; one general utility man at the power plant, and one laborer at each substation, whose only duty is to see that everything goes on properly, the machinery being automatic and operating continuously. At night the general utility man is not on duty.

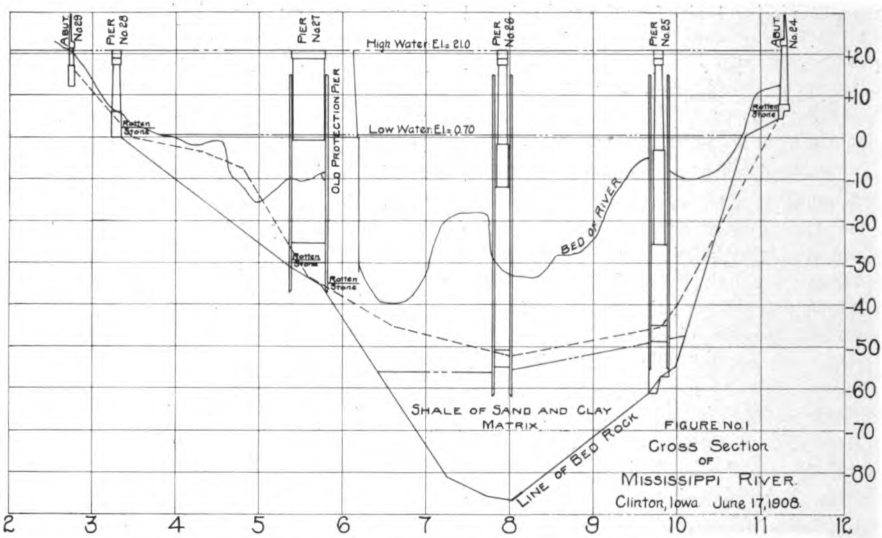
It is expected that before the field is entirely worked out, six to seven of these substations will be in use.

The officers of the Cowanshannock Coal and Coke Co. are: Mr. Adrian Iselin, President, New York City; Mr. Lucius W. Robinson, Punxsutawney, Pa., Vice-President and General Manager; Mr. James Craig, Yatesboro, Pa., Superintendent; Mr. Alexander Pride, Assistant Superintendent; and Mr. Chas. M. Means, Punxsutawney, Electrical Engineer. Mr. Robinson is also President of the Jefferson and Clearfield Coal and Iron Co., and President and General Manager of the Rochester and Pittsburg Coal and Iron Co., and Mr. Means is Electrical Engineer for these two companies as well.

The work of planning and installing the new power system devolved upon Messrs. Robinson, Means, and Craig, who deserve much credit for the responsibility assumed in evolving and carrying through such a radical plan to successful completion.

The writer is indebted to Messrs. Craig and Means for the information used in this article. The photographs reproduced were taken in August of this year, especially for this purpose.

Rural Valley substation; bore-holes for air, electricity, and water at the right.



TESTING FOR BRIDGE FOUNDATIONS.

*By F. H. Bainbridge,

RESIDENT ENGINEER CHICAGO & NORTHWESTERN RAILWAY CO.

This article is confined to bridge foundations, although much of what follows is also applicable to foundations for buildings and hydraulic structures and preliminary examination for tunnel construction.

GENERAL CONSIDERATIONS.

Two methods of testing only are effective, an open pit or well for shallow foundations and the core drill for deep foundations. Sounding with gas-pipe or rods in shallow foundations and the common well-drill in deep foundations are not satisfactory. Figure 1 shows two cross-sections of a stream at the same point, the dotted line being the line of supposed ledge-rock as determined by a well-drill operating a chopping bit; and the full line, the correct location of the ledge-rock, determined with a Sullivan "HN" Diamond Core Drill.

In general, two sets of borings should be made for an important bridge crossing; the first set, a number of borings on the center line of the proposed location, to determine whether the site is a favorable one, and, if favorable, to determine by approximate estimate the most economical location of the piers and the length of the spans. In a general way it may be assumed that the economical relation is reached when the cost of the substructure equals the cost of the superstructure; but inasmuch as the cost of the superstructure can be determined with considerable accuracy, while the cost of the substructure is involved in great uncertainty, the length of the spans selected should exceed that of the apparent economical relation. The length of spans chosen may also be influenced by other than economical considerations, such as government requirements, or the liability of ice to gorge against the bridge.

*Clinton, Iowa.

Having made a tentative location of the piers, borings should be made at each pier, and in the case of pneumatic or open dredged caisson foundations, one boring should be put down at each of the four corners of the caisson.

The preliminary borings may often be dispensed with when there are well records on both sides of the river in the vicinity. These well records can almost always be found in the various State Geological Reports, which can be had at any public library in the state. In case of the borings at Pierre, South Dakota, to be described later, the well records were so good that borings to determine the length of the spans were not necessary.

In cases where pile foundations are feasible and the river bottom is firm enough to lay concrete on, no borings are necessary, the required length of piling being best determined by driving experimental piles; but where the river bottom is soft, as it is in most streams with a sluggish or reversing current, borings should be made, the softer material being taken out *dry* with a saw-tooth bit. This is feasible in the hardest clay or the softer shales and gives a perfect knowledge of the material encountered. Unless dry cores are taken when feasible, a hard clay in every way suitable for a foundation may be overlooked and provision made for carrying the foundation farther down than necessary.

VALUE OF BORINGS.

In pneumatic work an accurate set of borings with a core drill is of incalculable value. These advantages are:—

1st. The final location of the caisson can be accurately determined and cut stone and timber ordered without any waste or delay waiting for material for which no provision had been made.

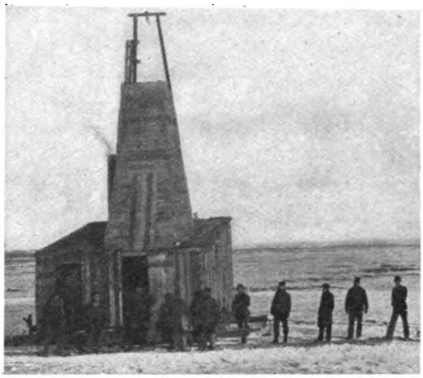
2nd. The contractor in bidding on the work knows exactly what material is to be encountered, and will make a lower bid when there is no uncertainty. The difference in cost between handling in a caisson, material which can be taken out through the blow-pipe, and material which must be locked out in buckets is very great.

3rd. The piers can be located in the most economical position. Often a change of a few feet in locating a pier may make a difference in cost of tens of thousands of dollars.

4th. Much can be learned as to the character of the foundation that cannot be learned from the interior of the caisson. In limestone formations subterranean caverns are common, and in both lime and sandstone formations overhanging subterranean cliffs are found. The existence of these can be determined with the drill, but cannot be learned from the interior of the caisson.

INTERPRETING THE BORINGS.

Nearly the whole North American Continent north of the Ohio River and east of the Missouri River has at various periods been covered with glacial drift; in fact, the Ohio and Missouri Rivers were formed by glacial action. Below the recent alluvial deposits in a river-bed in this district will be found glacial deposits of sand, gravel, clay, till, or boulders, sometimes all together in a heterogeneous mass. The extreme determined movement of the greatest glacial sheet was 1,500 miles. Boulders of granite from Canada and Minnesota were carried as far as Kansas and Missouri. One of the boulders in the river-bed is therefore liable to be mistaken for ledge-rock. Usually the character of the ledge-rock can be learned from state surveys and samples secured from the outcrops,



Testing Missouri River bed for bridge foundations at Pierre, S. D., on the Chicago and Northwestern Ry.

which are located in these surveys. When a core is obtained which can be identified as the same as ledge rock it may or may not be the actual ledge. If the core is granite or some older formation than the ledge-rock it is certain that a boulder has been reached. More recent rocks sometimes exist as pockets in earlier formations, so that a mere difference in the character of the rock from the bed-rock is not conclusive evidence that bed-rock has not been reached. When such a condition is liable to be found in any locality it will usually be mentioned in the State Geological Surveys. Boulders of granite and other hard rocks must be removed by placing sticks of dynamite at the bottom of the stand-pipe, withdrawing the pipe, and exploding with an electric battery. Boulders of softer rock can be cut up with the chopping bits and the casing driven through them. As boulders are usually separated by a matrix of sand or clay, the drop of the rods and the wash will show them as boulders and not bed-rock in most cases, though this is not always conclusive, as pockets sometimes filled with sand are common in limestone ledges.

No definite rules can be given to cover all cases, and it is best, especially where there is any uncertainty, to put down a hole at each of the four corners of a pier. Where the drill strikes first rotten or sap rock, gradually increasing in hardness until known ledge-rock is reached, this is conclusive evidence of bed-rock. It is best to take out very soft rotten rock with a saw-tooth bit working dry.

PIERRE, SOUTH DAKOTA, WORK.

Drill tests for the foundations of the Chicago and Northwestern Railway Bridge across the Missouri River at Pierre, South Dakota, were begun in December, 1905. The drill used was a Sullivan Machinery Company's "HN" Diamond Drill, operating two-inch core bits; 4½-inch stand-pipe and three-inch casing, both with flush joints, were used. Borings at the sites of the river piers were made from the ice. In general four holes were put down at the site of each pier. On diagonally opposite corners holes were put down to about 90 feet below low water, and on the other two corners to 60 feet below low water. Thirty-three holes in all were put down, aggregating a length below the river-bed or ground level of 2,379 feet, of which 1,456 feet was in sand, gravel, and boulders and 923 feet in shale, with occasional small lenticular pieces of limestone. On the east or left bank heavy beds of glacial drifts were encountered and there was some difficulty in putting down stand-pipe and casing. The boulders were broken up with dynamite. In shale, saw-tooth bits were used entirely, the bortz bit being used only in the limestone pockets.

The work of setting up the drill was started December 5, 1905, and the first boring started December 8, 1905, with one shift working 10 hours. On January 17, 1906, a second shift working 10 hours was put on.

Shale was found practically level over the entire cross-section at 42 feet below water. There was apprehension upon encountering an underground flow

Sullivan "HN" Diamond Drill testing the bed of the Mississippi at Clinton, Iowa.

of water in the upper strata of the shale, but in no case was this more than a few feet below the top of the shale.

Caissons for the permanent piers penetrated the shale from four to six feet and the material encountered was accurately described in the record of the borings. The cost of the drilling, including 10 per cent. for depreciation of plant and tools, was about $2,400, or about one dollar per foot. The photograph on page 242 shows the drill shanty on the ice of the river.

DRILLING AT CLINTON, IOWA.

In 1908 the Northwestern Railway began tests to locate suitable foundations for a new bridge over the Mississippi River at Clinton, Iowa. The same apparatus, tools, piping, etc., were used as at Pierre, but the manner of working and the materials encountered were essentially different. These borings were started in April, and it became necessary to mount the drill on a scow. The photograph on this page shows the drill mounted ready for work. The scow was 15 feet wide, 32 feet long on the bottom and 37 feet long on top, with a draft of 16 inches when loaded. Experience in rough water showed that a scow 10 feet longer on top with somewhat more rake to the ends would have been more serviceable. The tripod consisted of three pieces of Douglas fir, 5 by 8 inches and 32 feet long. An eight-inch wrought-iron pipe near the center of the scow, bolted with a pipe flange to the bottom of the scow, made a well for passing the stand-pipe, 4½ inches in diameter, and the casing, three inches in diameter.

The materials encountered were in order as follows: Recent alluvial sands, glacial drift of gravel, sand and boulders,

a shale consisting of sand with a clay matrix, and finally limestone bed-rock. The upper strata of bed-rock was identified by fossils and general appearance as belonging to the Gower stage of the Niagara Series of Silurian Rocks. This overlaid conformably rock of the Delaware stage of the same series. In the middle of the river the Gower rock and nearly 50 feet of the Delaware rock had been entirely eroded. Great care was taken to ascertain the possible existence of subterranean pockets or overhanging cliffs in the rock. Only two of these pockets were found, however, both in the same boring, and these were only one and six inches in depth. Both were filled with sand, consisting of about equal parts of quartz and dolomite sand. Some of the borings were carried down 30 to 40 feet into the bed-rock to determine the possible existence of these subterranean pockets.

All the boulders encountered were such as could easily be broken with the chopping bit and no dynamite was found necessary. To determine the consistency of the shale, cores were taken out with saw-tooth bits working dry, showing perfectly the consistency of the material. The saw-tooth bit or the chopping bit working with the pump gave no idea of what this material was, and without the expediency of the dry core an excellent foundation would have been overlooked, and a foundation sought 30 feet lower. It is intended to use pneumatic caissons in all the piers except the shore piers.

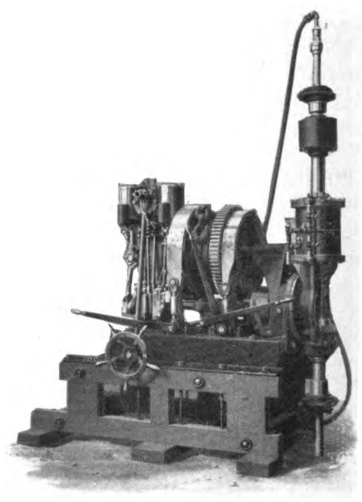
Borings in the limestone were made with a bortz bit when the water was still, and with the chopping bit, taking occasional cores with the saw-tooth bits. Fully 95 per cent. of the boring in the limestone was made with the bortz bit. The work of mounting the drill was started April 2nd, and the first hole begun April 7th. The work was finished June 6th, working one shift of 10 hours per day.

The aggregate length of casing put down was 692 feet. The aggregate length of casing driven through hard material was 406.5 feet. The aggregate length of borings in shale was 86 feet, and in limestone, 226 feet. The cost was as follows:—

Labor	$456.16
Coal	124.41
Depreciation of bortz, estimated	200.00
Scow	287.24
Depreciation on tools, pipe, etc.	200.00
	$1,267.81

The scow still has a value which is somewhat uncertain. Omitting this credit, the cost of the work amounted to $1.83 per foot.

The Board of Water Supply of New York City is preparing to drive a tunnel under the Hudson River at Cornwall, N. Y., for its new aqueduct. Four 3,000-foot Sullivan drills are to be used for testing the rock below the river-bed by means of horizontal holes bored from shafts on each bank.



Sullivan "B" Drill, capacity 3,000 feet.

MACHINE COAL-MINING IN ILLINOIS.

The Illinois Coal Report for 1907 has just been issued by the Bureau of Labor Statistics—Mr. David Ross, Secretary. It shows a total tonnage for the year, of 47,798,621, as against 38,317,581 for 1906, an increase of 9,481,040 tons, or 22.1 per cent. Of the total amount, 14,490,454 tons were cut by machines, or 30.3 per cent. of the total. In 1906 only 24.9 per cent. of the total product was machine mined, showing a gain of 21.7 per cent. in the use of machines.

"The mines reporting the exclusive use of machines increased only five per cent over last year, and the number of machines used only nine per cent., while the tons mined increased 36.6 per cent. The total number of mines using machines increased 18.8 per cent. over last year; the number of machines 14.9 per cent., and the number of tons cut 51.5 per cent., showing certainly a remarkable increase in the effectiveness of machine mining.

"Table 58 presents the record of mining machines in use in the coal-mines of the state for a series of eight years. The number of machines in use this year was 1,105. This is 143 more machines than reported for last year. Several of the different kinds of machines have largely increased in the number in use during the past few years."

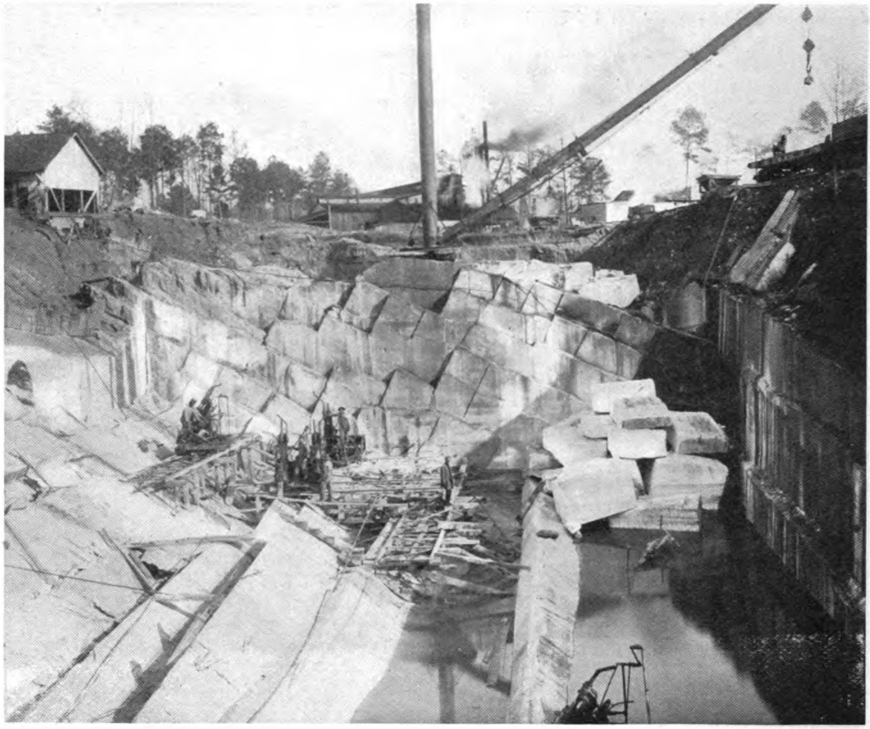
TABLE 58—*Name and Number of Mining Machines in Use for Eight Years.*

Year.	Sullivan.	Ingersoll-Sergeant.	Harrison.	Goodman.	Morgan-Gardner.	Jeffrey.	Herzler & Henninger.	Yock.	Link Belt.	Lee.	Butler.	Total.
1900	40	119	197	....	19	30	1	5	19	..	.	430
1901	33	132	178	....	32	33	13	24	19	..		464
1902	36	133	160	29	22	32	20	28	3	..	2	465
1903	82	95	178	15	15	50	33	31	21	..	2	522
1904	131	142	210	29	27	29	22	27	4	..	2	623
1905	183	178	236	49	19	41	40	33	4	..	1	784
1906	315	197	244	82	28	33	35	25	....	3	..	962
1907	427	221	195	112	74	35	26	8	4	3	..	1105

An interesting fact in connection with machine mining in this state is that the opposition to the use of machines on the part of labor is such that machines in mines where hand labor also is employed cut less coal than mines using machines altogether. Thus, in the sixth district, two exclusively machine mines working 18 machines produced 529,012 tons, while in two mines where hand miners were also employed 12 machines got out only 281,242 or 29,389 tons per machine in the first instance, against 23,437 in the second. In the eighth district, 235 machines cut 13,715 tons each in exclusively machine mines, while 126 machines in mines where hand labor was used jointly cut but 11,000 tons each. The total for the state shows that 748 machines are used in 60 mines where no hand mining is done, and that 357 machines mine a part only of the product of 41 other mines. The first machines average 13,950 tons. The second, 11,361 tons, or 18.5 per cent. less.

Another source of economy traceable to the use of machines for undercutting the coal is the saving in powder. In 280 mines where hand labor—*i. e.*, shooting from the solid, without undercutting—is customary, 1,003,371 kegs of powder were required to shoot 25,865,287 tons, or 25.78 tons per keg. On the other hand, in 57 mines in which the coal was all undercut by machines 10,426,460 tons were broken down by 108,584 kegs of powder, giving an average of 96.02 tons per keg used. At $1.75 per keg, this shows a powder charge of 6.8 cents per ton on hand-mined coal, and of 1.8 cents per ton on machine-mined coal.

Sullivan Diamond Drills were recently employed by the Water Power Commission of Austin, Texas, and by the United Missouri River Power Company of Helena, Montana, in locating suitable foundations for dams. The drills were mounted on scows.



Gantt's Quarry, Alabama

ALABAMA MARBLE: HISTORY, PRODUCTION, AND USE.

Gantt's Quarry, three miles from Sylacauga, in Talladega County, and 50 miles from Birmingham, is the site of quarries which give Alabama high rank as a marble-producing state.

These deposits were discovered in 1836 by a Scotchman named Herd; in 1845 Dr. Edward Gantt began work in a small way, with primitive methods. Slave labor was employed, and the blocks were lifted with wooden wedges. These blocks were used principally for headstones and slabs, which may still be seen in many of the cemeteries all over the state.

The war halted these operations, and as Dr. Gantt died in 1867, the quarries lay idle for nearly 40 years, until northern capital was interested and the property bought at a court sale in 1898. The Alabama White Marble Company was formed and work begun on a small scale, but it was not until 1902 that public attention was drawn to the superior qualities of this marble, by a block exhibited at the Alabama State Fair at Birmingham. It is interesting to note that the Vermont Marble Co., the largest producer in America, examined the property in 1878. The late Senator Proctor reported the marble as undesirable and the physical conditions adverse to successful operation.

These deposits include both blue and white stone, but at present the white only is developed. Some of the layers are of a rich creamy tint, and some have

the bluish white tinge of Italian marble.

There are also layers which yield veined or clouded slabs, presenting a variety of effects for decorative purposes. The cream white, however, is the chief product of the quarries. These marbles are declared to be the equal of Greek and Italian marbles in their life, warmth, and permanence of color; and superior even to these in their adaptability for carving, matching, and other monumental and structural purposes.

SIZE OF SLABS.

A distinguishing characteristic of Alabama marble is the large size of slabs that can be secured from it. With sufficient notice to allow for quarrying, slabs can be obtained of any size, limited only by the capacity of the saws available. This will enable architects to adopt designs for panels with dies larger than any hitherto obtainable. The resulting possibilities, where a noble and dignified interior marble treatment is desirable, will be readily appreciated.

DURABILITY AND STRENGTH.

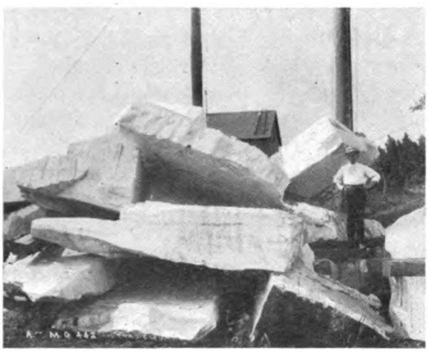
Alabama marble is an exceedingly pure calcium carbonate, the proportion being about 99.4 per cent. Of iron there is barely a trace, and of iron pyrites there is none. It contains nothing that would promote either staining or chemical disintegration. Its durability is amply attested by old tombstones, over fifty years old, on which the carving and tool marks are as fresh and perfect today as when the work was done. The weathered surfaces on the old outcrops, as they are uncovered at the quarry, show a thin skin, not more than one thirty-second of an inch thick, of material that is slightly softened; below the skin the marble is as sound and hard and pure as it is a hundred feet down in the deposit.

The crushing strength of this stone, *in three-inch cubes*, is from 13,000 to 17,000 pounds per square inch. Its strength is more than ample for all purposes. When cut with the beds, it is also possessed of very great transverse strength. This has never been tested accurately, but at the company's mill its employes carry thin slabs by the edges, in a horizontal position, with perfect safety, which, in any other marble, would inevitably break under their own weight.

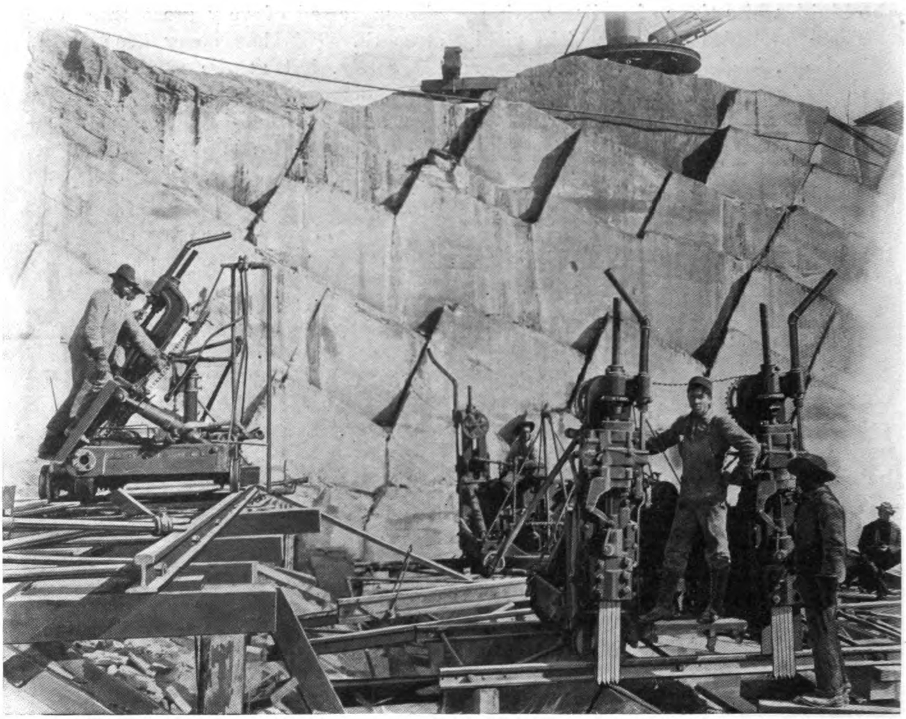
PRESENT OPERATIONS.

The Alabama White Marble Co. was succeeded in 1906 by the Alabama Cream White Marble Co., with a capital stock of $1,000,000. The company name has recently been altered to The Alabama Marble Co.

The photographs on pages 246 and 248 show the character of the development. Since the picture on page 246 was taken, the quarry has been extended behind the derrick in the center, and is now 85 x 350 feet in area. The company's property covers 680 acres, which includes a vein of white marble a mile long and 500 to 600 feet thick. The deposit, as shown by the photographs, dips at an angle of about 35 degrees, and the layers are from two to five feet in thickness. Thorough prospecting with a core drill shows that the marble persists to a depth of 320 feet under the present quarry. Twelve bore holes, drilled in various parts of the vein, have failed to find bottom. The overburden consists



Quarry blocks of Alabama marble.



Quarry of Alabama White Marble Co., Gantt's Quarry, Alabama, showing Single- and Double-Head Sullivan "Z" Channelers.

of light soil, about 15 feet in depth, which renders stripping comparatively easy.

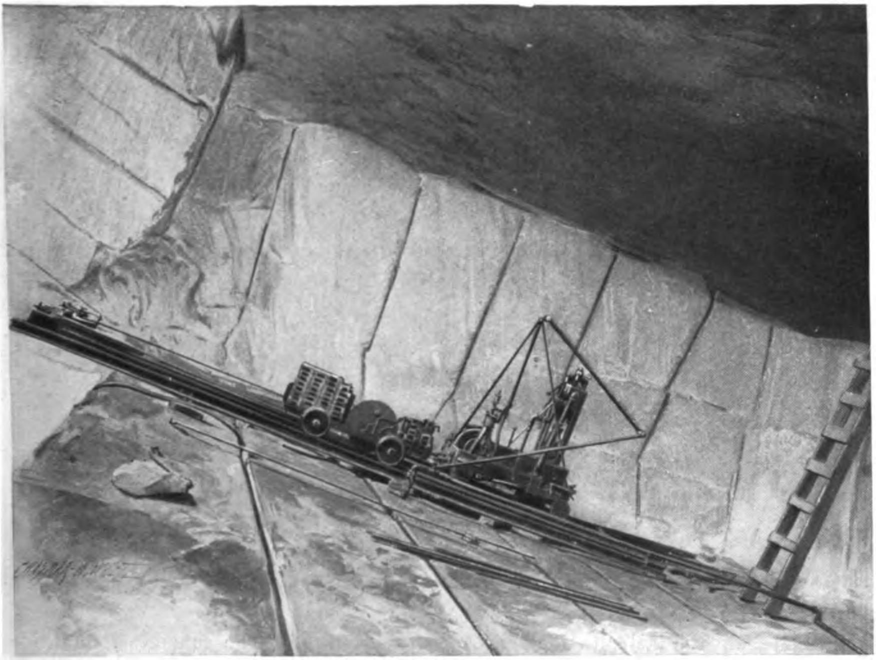
CHANNELING.

The photographs show clearly the methods used in quarrying this deposit. The steep pitch of the beds presents some difficulties not encountered in other fields. Sullivan Class "Z" Swivel-Head Channelers are employed for ordinary work, using regular five-piece gang marble bits. It is necessary to prop up the track for these machines with short posts, as shown in the pictures, to give the channelers a level plane on which to operate. The cuts across the pitch, lengthwise of the quarry, are put in at right angles to the layers, which makes it necessary to swing the cutting engines of the channelers at an angle of about 35 degrees from the vertical.

These channelers are designed especially for heavy work and rapid cutting under conditions of this nature.

In cutting up to the end walls, the cutting heads may be swiveled on a steel plate, to put in transverse cuts in the same plane as the floor channel, up to 30 degrees, if necessary.

When cutting up and down the pitch, across the quarry, three methods are used: drilling and broaching with rock drills on quarry bars, as shown in the photograph on the front cover; "Z" channelers, on track made level by props or cribbing (see above cut); or third, and usually, when long runs are possible, by



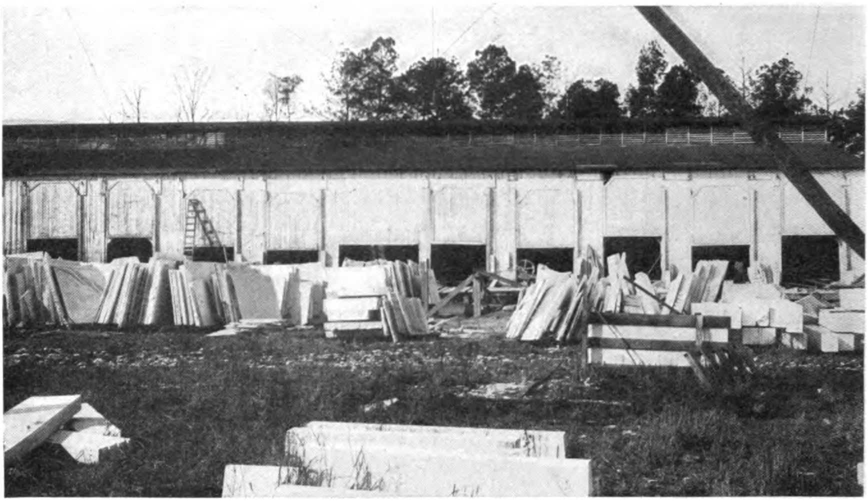
Sullivan Side-Hill Channeler, "Class 6½," in West Rutland quarry of Vermont Marble Co. Instead of winding the cable on a drum on the axle, as described in this article, the cable here passes over a sheave and is attached to a counterbalance car running on rails parallel to the machine track.

means of a Sullivan Class "6½" Side-Hill Channeler. This machine is lighter than the Class "Z," and the axles of the trucks are provided with drums, to which a wire rope is attached. This rope passes around a sheave wheel at the upper end of the track, and is wound up or paid out by the feed engine on the channeler. This machine cuts at an even rate of speed up or down the incline of about 35 degrees. The trucks are gibbed to the rails to prevent overturning. As all cuts are made to the bed planes, very little drilling is required to raise the blocks, but, instead, wedges are driven into the split. The company employs seven Sullivan Channelers, three Class "Z," one "double-head" "Z" machine with two cutting engines mounted on the same frame, the "6½" side-hill channeler referred to, and two Class "VX" side-hill machines, which are also used somewhat for the hill-climbing work and for other lighter channeling, for which they are well adapted. These machines run on a track with a rack-rail, which is engaged by machine-cut teeth on the wheels.

The drilling is done with Sullivan 2¾-inch Rock Drills, mounted on four Sullivan quarry bars, and with 2½-inch Sullivan tripod drills.

FINISHING PLANT.

When cut into blocks of the desired size, the stone is hoisted from the quarry by two wooden 20-ton derricks, one at each end, and by one new 35-ton steel derrick in the center of the quarry, with a 100-foot mast and 95-foot boom. The photograph on page 247 shows the appearance of the blocks as they come from



Part of the mill and shipping yard, Alabama Marble Co.

the quarry. The equipment for handling the stone between the quarry and the mill, and from the latter to the railroad cars, includes a 75-horsepower hoisting engine, a 20-ton locomotive crane, and a 35-ton dinkey locomotive. A 15-ton traveling crane is about to be installed between the mill and the finishing plant; it will be 70 feet long, with a 26-foot lift.

The photograph on this page shows a portion of the mill, which is now being enlarged. The new plant will be 51 x 300 feet, and will contain 20 gang saws, five rubbing beds, two fitted with tile machinery, six polishers, a combined circular and straight-line planer, a diamond saw and carborundum machine, and a lathe 16 feet long with four-foot swing.

POWER PLANT.

A new 500-horsepower simple Corliss engine will drive the saws direct, and will furnish power to a 200-KW generator for operating the other finishing machinery electrically. Air hand tools for carving and finishing are supplied with power from an 1,800-foot cross compound, two-stage compressor, recently installed.

Steam is provided at 160-pounds gauge pressure, with 125 degrees of superheat, from two 300-horsepower vertical water-tube boilers. The concrete foundations for two more 300-horsepower units are already set. The steam pressure in the mains which supply the channelers and drills is reduced to 120 pounds.

The plant now employs about 175 men, and more will be added when the new finishing plant is completed. Railroad facilities are provided by a spur track, connecting with the Louisville & Nashville Railroad.

EXAMPLES OF USE.

For interior finish, Alabama marble from the quarry of this company has been used in New York City, in the rotunda and other parts of the main story of the new Customhouse, in the Night and Day Bank, and in the banking-room of the new building of the Trust Company of America, No. 37 Wall Street. It has also been used in the National Metropolitan Bank, opposite the Treasury Department, in Washington, D. C.; in the Brown-Marx building and the Florence Hotel in Birmingham, Ala.; and in numerous other buildings.

For exterior work, Alabama marble from Gantt's Quarry has been used in the Maryland institute, in Baltimore, Md.; in the Connecticut Savings Bank, in New Haven, Conn.; in the new Court-House at Somerville, N. J.; and in other buildings.

The officers of the company are Henry Evans, President, New York; Major John Stephen Sewell, Vice-President and General-Manager, Gantt's Quarry, Alabama; G. T. Hollister, Vice-President, New York; E. E. Bigoney, Secretary and Treasurer, New York. A sales office is maintained at 156 Fifth Avenue, New York City, and an office and ware-rooms at Avenue E and 21st Street, Birmingham, Ala. The company has a large number of orders for all classes of work now on hand, and looks forward to a rapid increase in the popularity of Alabama marble.

MINE AND QUARRY is indebted to Major Sewell and also to the ***Manufacturers' Record*** for the information contained in this article.

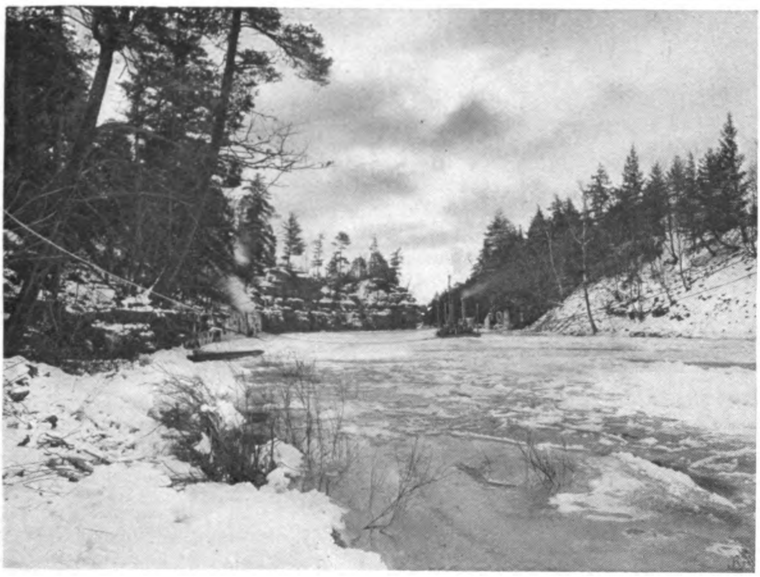
PROGRESS ON THE ASHOKAN DAM.

By Joseph H. Brown, Jr.*

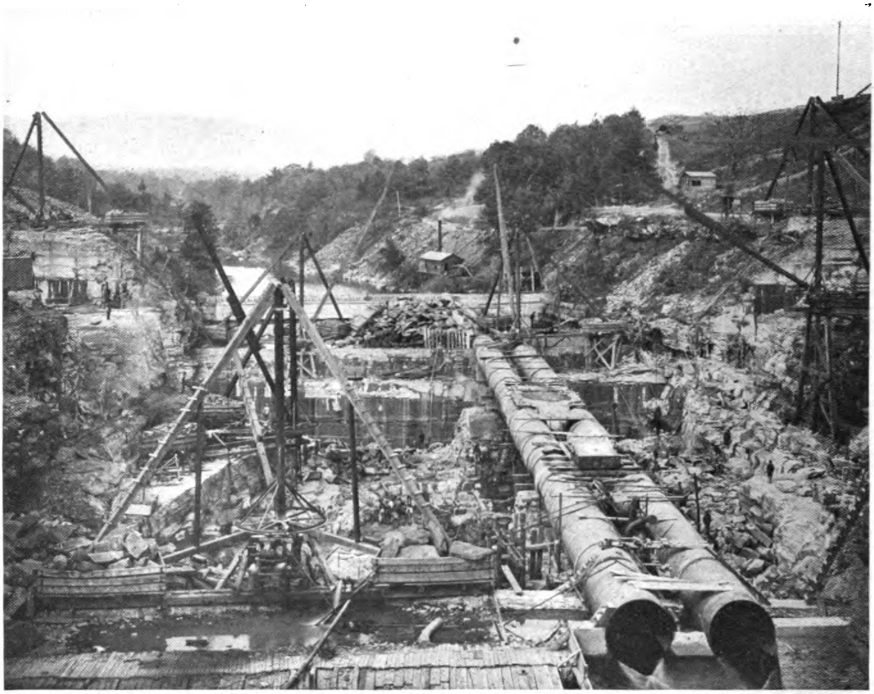
The Ashokan Dam, now under construction near Brown's Station, Ulster County, New York, forms a part of the new water system which the Board of Water Supply is establishing for the City of New York. The contractors for the work are MacArthur Bros. Co. and Winston & Co., builders of the Wachusett Dam, in Massachusetts, and the Cross River Dam at Katonah, New York.

Masonry and earth dams across the Esopus and Beaver Kill Creeks and across low portions of the valley will form a storage basin about 12 miles long and one mile wide, with a capacity of

*42 Broadway, New York.



Sullivan Diamond Drill testing the bed of Esopus Creek, Brown's Station, N. Y. on the site of the Olive Bridge Dam.



General view of Ashokan Dam construction in September, 1908, looking up-stream.

120 billion gallons, the largest reservoir in the world for high-pressure water supply. The total length of these dams and dykes is nearly four miles. The water collected will cover the ground now occupied by 11 villages, to an average depth of 18 feet, forming an area of 8,000 acres, with a shore line of 50 miles. It is the intention of this article to deal merely with the main dam—known as the Olive Bridge Dam—across the Esopus Creek.

At the site of the dam, the Esopus Creek originally ran through a rock gorge about 200 feet wide and 40 feet deep. The rock is a hard, blue sandstone, very gritty, occurring in nearly horizontal layers from three to four feet thick, and occasionally interspersed with slate and shale.

Across the channel, above and below the dam, cofferdams were built by the Board of Water Supply prior to the letting of the contract, and two riveted steel pipes, eight feet in diameter, now carry the flow of the creek.

The dam is to consist of a concrete masonry portion 190 feet wide at the base, about 1,000 feet long, and 250 feet from the bottom of the cut-off to the crest. On each end of the masonry section there will be wing dams of earth with concrete core walls, making the total length of the dam 4,800 feet. The cross section is similar to that of the Wachusett Dam.

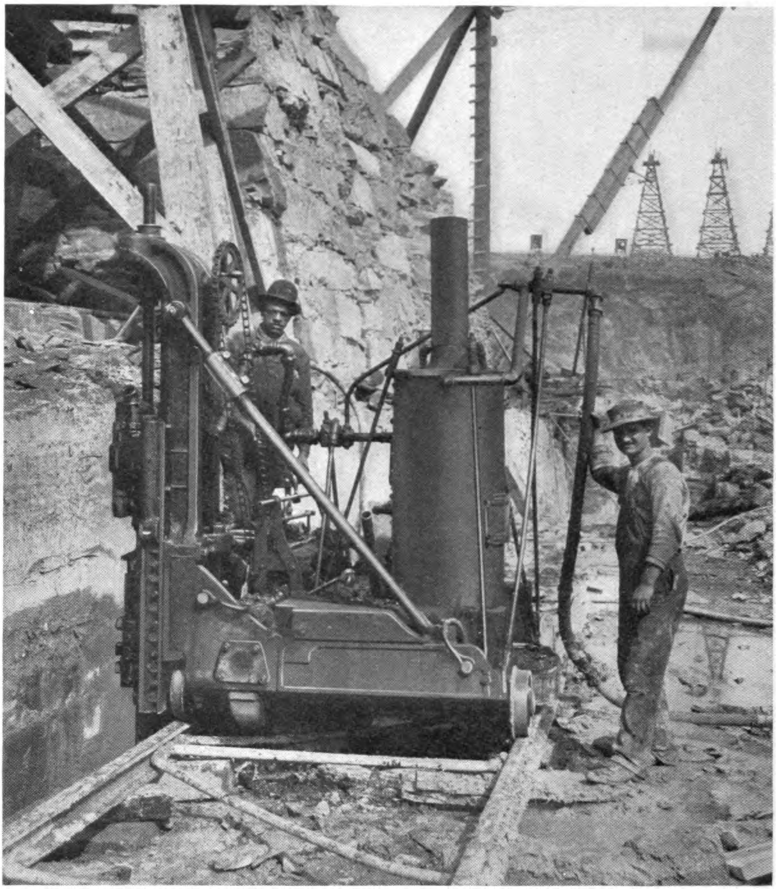
In order that all water-bearing seams under the dam may be sealed, a cut-off 25 feet wide has been excavated across the creek, going down 40 feet below the level of the foundation of the dam. To avoid disturbance of the existing rock

Cut-off at Ashokan Dam; Sullivan Channelers in rear. The material between the walls is removed by drilling and blasting.

by blasting, channeling was resorted to, and four Sullivan Class "Y-8" Channelers with air reheaters were installed. Both sides of the cut-off were channeled in lifts averaging six to eight feet. The bit used is the three-piece gang, made up of three pieces of 2¼- x 1⅛ inch steel, which was found to be the most satisfactory for this work. The cut-off is completed in the bed of the creek and is now being extended into the sides of the gorge to a line about 100 feet above the foundation level, where the rock ends. This part of the work will look roughly like a flight of steps in section. At the time of writing it is estimated that there is still about 100,000 square feet of rock to be channeled.

Above the cut-off the rock bottom has been prepared for the placing of Cyclopean masonry, which has already begun. Solid masonry piers are under construction to support the pair of pipes, to guard against danger from the overflow of ice in the coming spring. As soon as the masonry of the dam reaches the level of the pipes, a conduit will be built through the dam into which the stream will be diverted. The pipes will then be removed, the piers under them forming an integral part of the dam.

All machinery except steam shovels, locomotives, and the crushing and mixing plant is operated by compressed air. Power is at present furnished by two cross-compound condensing, two-stage



Sullivan "Y-8" Channeler run by air, on the second "lift."

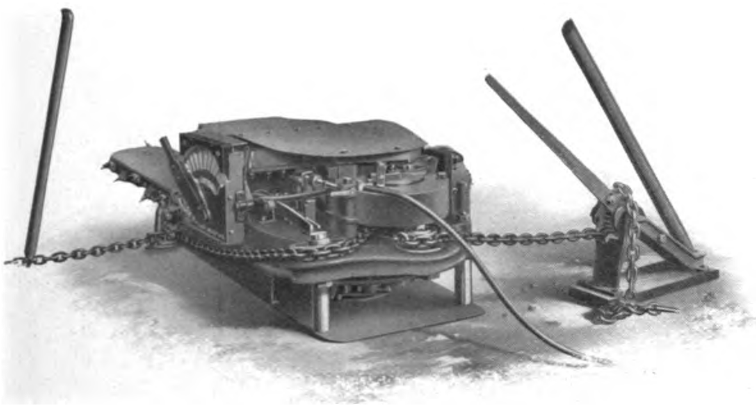
air compressors with a combined capacity of 7,000 cubic feet of free air per minute. A third unit is practically installed and the foundations for a fourth are in place.

When all the compressors are in operation, a uniform pressure of 100 pounds per square inch will be maintained.

Four 15-ton cable-ways are in operation. The towers have a movement of 700 feet at right angles to the axis of the dam, giving perfect control over the work.

Adjacent to the head towers of the cable-ways is the big crushing and mixing plant. Stone will be brought from the quarry, about two miles distant, over a railroad built by the contractors, which involves the construction of a bridge about 1,200 feet long over Esopus Creek.

At present there are about 2,000 men employed on the entire work. This number will probably be doubled before the reservoir is completed. A camp has been built to accommodate the workmen, with well-laid-out streets and a complete sewerage system. It is estimated that this small city will eventually have a population of between five and six thousand.



Sullivan Low-Vein Room-and-Pillar Coal-Mining Machine, Class "CE-6," with frame removed. Rear view, showing handling gear.

A NEW COAL-MINING MACHINE FOR LOW VEINS.

For several years the use of the Sullivan Continuous-Cutting Electric-Chain Coal-Mining Machine has steadily increased, as operators in various fields of this country have learned to appreciate its advantages. The success of this type has been such as to warrant the development of a similar machine for mining coal, both in rooms and on long-wall faces, in thin seams.

The Sullivan Low-Vein Room-and-Pillar Mining Machine, designated as "Class CE-6," is mounted upon a steel shoe or frame for convenience in transportation and for making its first cut. In making the first or rib cut, the machine moves forward out of this frame, which is cut away at the left-hand side. The rear or anchor jack is then set in the right-hand corner of the room, and the front jack at the other extremity of the working face. The machine propels itself across the face on a feed chain stretched between these two jacks, cutting the entire room at a single operation. The accompanying illustration shows the machine in the above position, with the two jacks.

It will be noted that the machine travels on a sheet-steel plate, occupying the least possible space. No rollers or rails are required on which to run the machine while making this cut. It will also be noted that this is virtually an adaptation of the long-wall principle to room work. The machine is not withdrawn from the coal after making the first or sumping cut until the left rib is reached.

This method accomplishes notable economies in mining and in handling the coal. Not only is much time and labor saved that is ordinarily employed in backing the ordinary type or breast machine out from the coal and moving it over by hand for the next cut, but as there is no frame or pan behind the machine, as in the case of the breast type, it occupies but one-half as much space as the latter in front of the coal, thus allowing props to be permanently set within six feet of the face, and reducing the distance which the coal and debris must be moved by the loaders. As the Sullivan machine cuts on the bottom, at all times closely following the contour of the

Crossing the face in a single operation, without withdrawing the machine from the coal or moving jacks.

floor, no coal is left after it, to be raised by hand, nor are sprags or ribs left at the rear of the cut to interfere with blasting to the best advantage.

The machine has been carefully designed to secure strength, durability, and at the same time low height and compactness of the working parts. The motor is placed horizontally instead of vertically, as is usual in the ordinary machines of this type, and is wound for 210, 250, and 500 volts direct current, as required by mine conditions. When cutting, the machine stands 21 inches high and occupies a space of five feet three inches between the coal and props. The kerf or height of mining is four and one-half inches, and the depth of cut ranges from 63 to 75 inches. The machine is moved from place to place in the mine on a special self-propelling electric truck. When on this truck the machine stands 30 inches above the rails, although, if desired, a truck is furnished with drop axles, reducing the total height to 27 inches. The machine performs all operations under its own power, including loading and unloading from the truck, so that hand labor is reduced to the minimum. The machine weighs 3,100 pounds and the power truck 900 pounds. The motor develops 30 horsepower at 1,125 R. P. M.

This coal cutter has proven very satisfactory to operators on account of its high cutting speed, from 16 to 39 inches per minute, small bulk and ease of manipulation and carriage. It is capable of operating on pitches of 30 degrees when rooms are driven across the pitch, and of 12 degrees when rooms are driven straight up the pitch. As indicating the capacity of this type, it may be mentioned that at the mines of the Gay Coal & Coke Co., Logan County, West Virginia, a Sullivan Class "CE" machine has undercut, on a long-wall face, 377 feet to a depth of six feet one inch in eight and one-half hours, thus producing over 500 tons of coal. While these machines naturally make a better showing in wide rooms, experience has shown

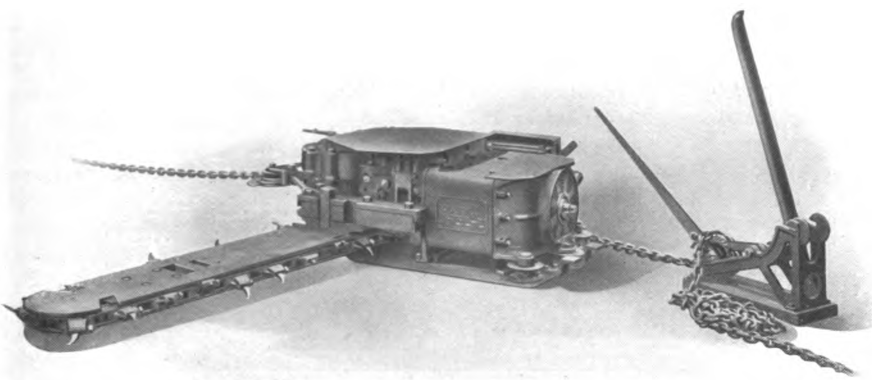
that they are also much more economical than the breast cutter in narrow rooms and even in entries.

In a mine at Murphysboro, Ill., a green runner has cut seven eight-foot entries in less than five hours, and later on cut eleven nine-foot places in 7½ hours, including two moves of over 500 feet each.

The following extract from the Brisbane, Queensland, *Daily Telegraph* for May 15, 1908, describing a visit to the largest colliery in Queensland, known as the Blackheath Mines, shows the impression made by machinery of this class upon a "layman":—

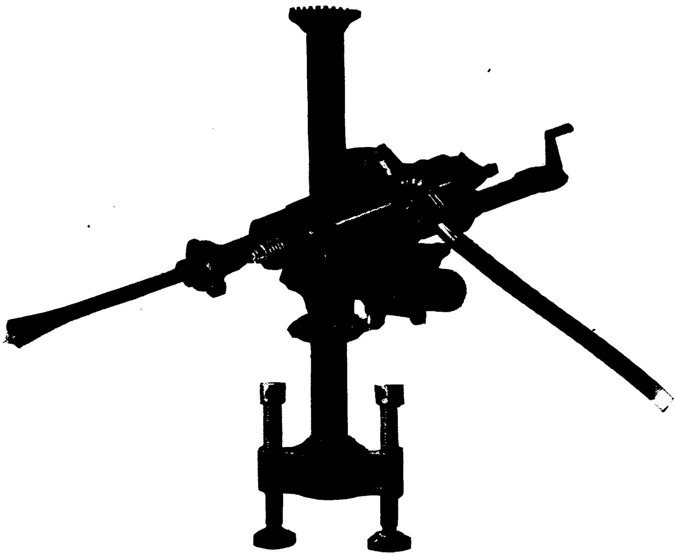
"At one place a most interesting exhibition of the wonderful, almost human, operations of a Sullivan coal-cutting machine was witnessed. This marvelous contrivance, which weighs about two tons, and which is operated by a 30-horsepower motor, capable of developing up to 50 horsepower, if need for so much power arises, was seen cutting at an astonishing rate of speed 6 feet 6 inches into the 12-foot wall, right across its 25-foot face, without a break. In performing this herculean task, the machine gradually hauled itself along the face, while its two attendants, together with the visitors, calmly watched its progress. Directed by the men, the machine afterwards pulled itself back to its truck, and, carrying with it all its necessary gear, eventually propelled itself away to another working until the 60 tons, which was awaiting the shock of the explosive, had been taken from the face first operated upon."

Sullivan Coal Cutters of this type have been in use for the past three or four years in Australian mines, with very successful results. In New South Wales, the principal coal mining field in Australia, there are 16 collieries employing mining machines. Sullivan machines are used in 12 of these mines. In the 16 machine mines there are 62 coal cutters of the chain type in use, of which 41 are of the Sullivan Class "CE" room-and-pillar type. There are also four class "CH" long-wall machines.



Electric Low-Vein Long-Wall Machine in position to cut from left to right. Height, 21 inches.

Sullivan Rock Drills

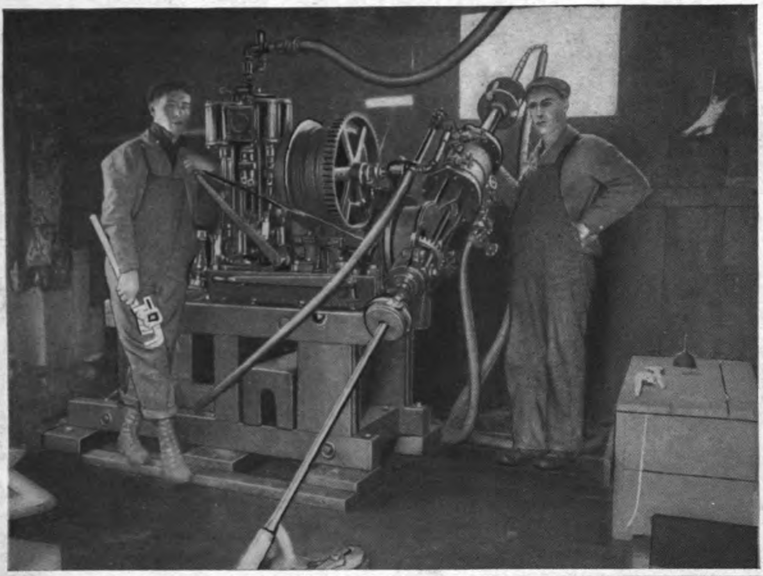


CATALOGUE 160

Sullivan Machinery Co.

MINE AND QUARRY

Vol. III. No. 3. MARCH, 1909

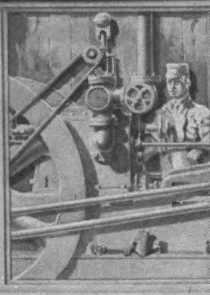


BORING AN ANGLE HOLE WITH A DIAMOND DRILL

AUTOMATIC STOPPAGE OF HOISTS

VERMONT MARBLE

DIGGING A SEWER WITH HAMMER DRILLS



PVBLISHED BY THE SVLLIVAN MACHINERY CO. RAILWAY EXCHANGE BVILDING, CHICAGO.

TABLE OF CONTENTS

PAGE

Editorial - - - - - - - - 257

Automatic Stoppage of Hoisting Engines - - - - - - 259
S. T. NELSON

Digging a Sewer with Hammer Drills - - - - 265
GEORGE D. HUNTER

Vermont Marble, Part I - - - - - - - - - - 271
ERNEST H. WEST

A Deep Diamond Drill Hole - - - - - - - - 275
(Special Correspondence)

The Bergen Hill Tunnel of the Erie Railroad - - - 279
SAMUEL SEAVER

Index, Vols. I - III - - - - - - - 284A

MINE AND QUARRY

VOL. III, No. 3 MARCH, 1909

A Quarterly Bulletin of News for Superintendents, Managers, Engineers, and Contractors.

Published by the Advertising Department of the Sullivan Machinery Company.

Address all Communications to MINE AND QUARRY, Railway Exchange, Chicago. Sent to any address upon request.

Readers are requested to notify MINE AND QUARRY of any correction or change in address.

The advantages of hammer drills for use in restricted places are well illustrated in the construction of a sewer trench at Bloomington, Indiana, described in another column. New applications for these handy tools are being discovered from day to day, in mining and quarrying, as well as in construction work.

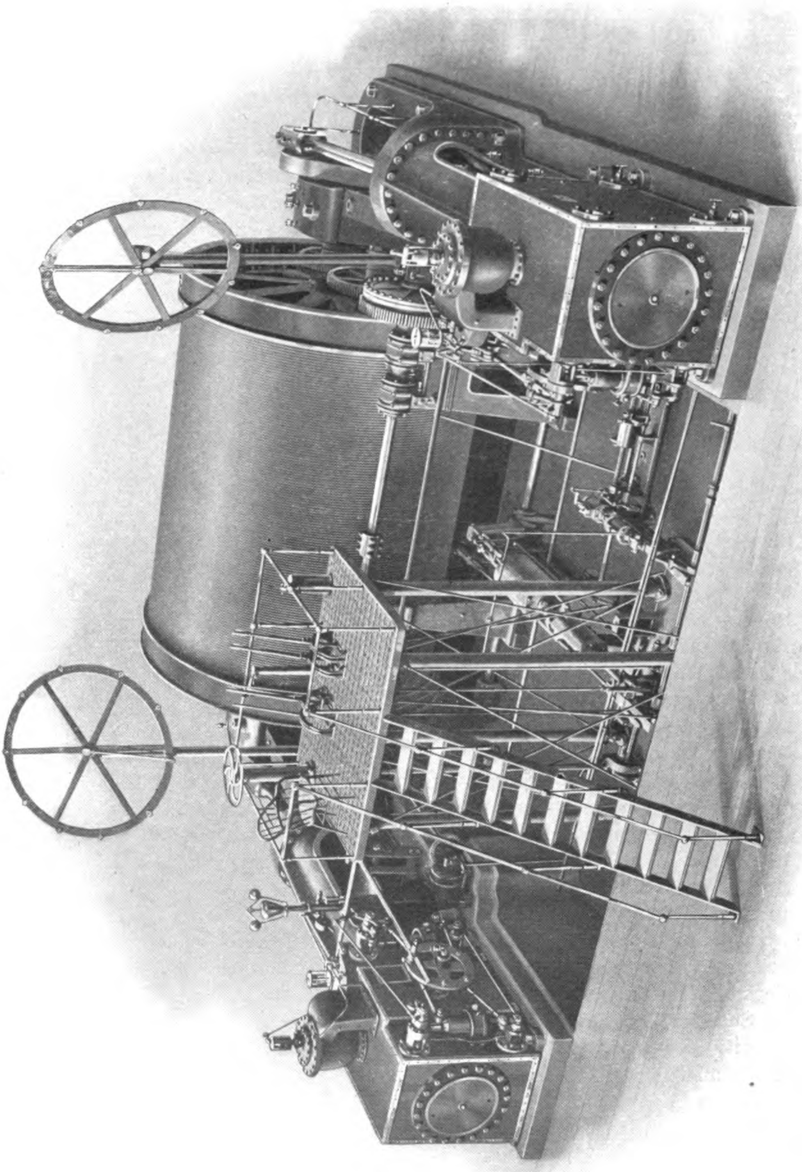
The question of safety appliances for hoisting plants is of constant interest to mine engineers in all parts of the world. Deep shafts and large production call for heavy loads and high speed, and many are the schemes which have been devised to give protection against accident in case of overwinding. Fair examples of these are devices for detaching the hoisting rope from the cage; the construction of head-frames with guides set converging to jam the run-away cage, and one theorist has seriously proposed a set of spiral compression springs to arrest the cage or skip. In the Lake Superior iron and copper mines, the severity of the conditions mentioned above has made necessary a solution of the problem giving more definite assurances of safety from loss to life and property. In this field, modern practice has obviated the liability of accidents from overwinding by making overwinding impossible. The human factor is nullified by making the stoppage of the hoist independent of the engineer. The safety appliances take effect automatically on the engine instead of on the cage, and before the cage reaches the landing instead of afterward. Engineers will be glad to read what the originator of this theory has to say on the subject, elsewhere in this issue.

This issue completes the third year of publication of MINE AND QUARRY.

It may be well at this point, to quote the purpose of this magazine, from the issue of May, 1906: "To familiarize its readers with the different classes of machinery manufactured by the Sullivan Machinery Co. This is frankly stated, at the outset, to avoid misconception in any quarter. This aim will be attained by descriptions of engineering, mining, and quarrying undertakings of special interest, in which the various machines have been or are employed; by mention and illustration of new machines and of improvements to existing types; and by discussion and suggestion regarding the best practice in the application, use, and care of machines under different conditions. Communications, suggestions, and inquiries from readers will be welcomed and will receive careful attention."

A glance at the index, page 284A, will serve to show whether another object—"To give circulation to news of modern methods, applied to engineering, quarrying, and mining work," has been attained.

Whatever interest or value the combination of these two objects may have is for our readers to say. The magazine will be continued during the current year, and suggestions and contributions will still be welcome.



Sullivan First-Motion Hoist of Centennial Copper Co., at Calumet, Mich. Dimensions: Engines, 36 x 60 inches; drum, 15 feet in diameter by 15 feet long, keyed to the shaft. This hoist has a capacity in depth of 5,000 feet and a hoisting speed of 3,500 feet per minute.

AUTOMATIC STOPPAGE OF HOISTING ENGINES

By S. T. Nelson*

It is nearly 28 years since the writer began the study of the hoisting engine problem in the Lake Superior iron mining region. After several years spent at the mines, he secured a position with the M. C. Bullock Manufacturing Co., of Chicago, then one of the best-known concerns in this line. The writer has been connected with that company and its successor, the Sullivan Machinery Co., for over 24 years, engaged in a constant study of hoist requirements and design.

CHANGES IN MINING CONDITIONS

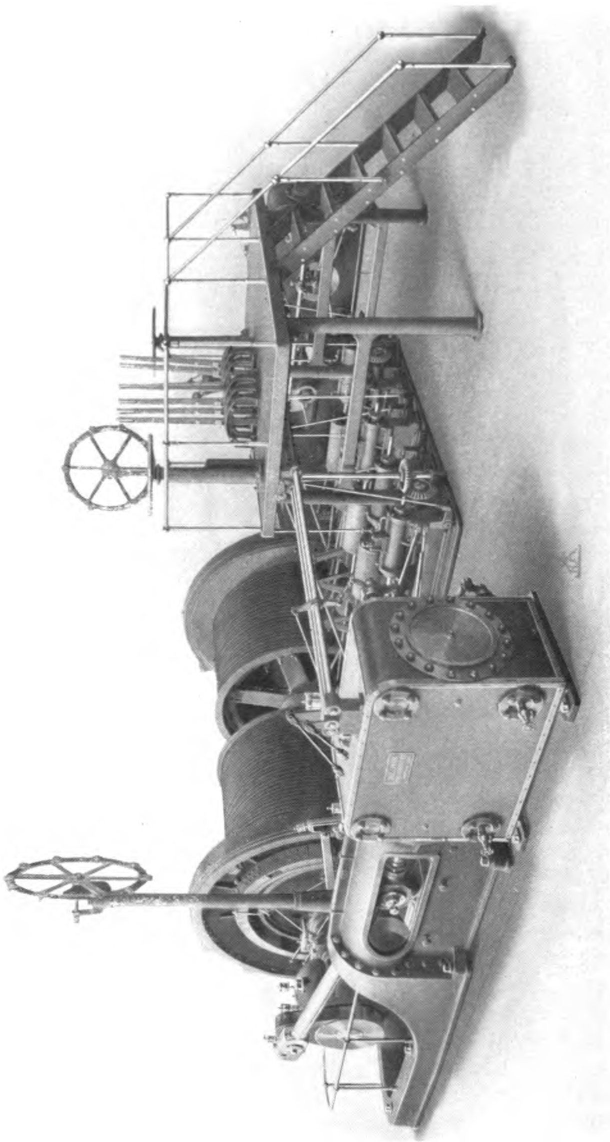
The design of Bullock and Sullivan hoists has thus progressed with the development of the Lake Superior country, to meet the constantly changing conditions of this, the most important mining center in the world. As the mines grew deeper and the tonnage hoisted increased, the speed of the engines was correspondingly increased. The first-motion hoist took the place of the geared hoist, and the more rapid hoisting speeds and more expeditious methods of handling necessitated by enlarged output, greatly enhanced the likelihood of overwinding, with its danger to life, destruction of property, and costly delay to mining operations; although in the early days practically the only danger to life from overwinding was to the men working on the dumps. As the mines were so shallow that the miners could walk up and down on ladder-ways, very few were hoisted and lowered with the hoisting engines. In fact, in most cases, this was prohibited. As the mines increased in depth, hoisting and lowering men with hoisting engines became necessary, and the danger due to overwinding became so great that it was apparent that some means must be provided to prevent accidents from this cause. A number of schemes were suggested and tried, and it is safe to say that these early attempts, although crude in comparison with present methods, greatly reduced the number of accidents.

These attempts toward lessening danger and decreasing accidents were considered favorably by only a few, as it was (one might say) in those days considered that a certain number of accidents would occur any way, and the idea of preventing them was thus lightly dismissed. Consequently, mining companies were not willing to pay a sufficient price to produce an automatic mechanism to prevent overwinding, that would give efficient results. People preferred to run the chances of an occasional accident, if they could not procure such a device at low cost. The few who were willing to admit that the automatic stoppage of hoisting engines could be accomplished, were skeptical about the advisability of complicating the mechanism of the hoist. Due to these objections, much time passed before users of hoisting engines were willing to consider in earnest the design and adoption of automatic devices for preventing overwinding. It was not until after the panic of '93–'95, which, by the way, brought about a decisive revolution in the mining industry, as well as in all other industries, that even a hearing could be gotten from any but a few of the most progressive mine managers. The new conditions called for heavier loads and greater hoisting speeds than ever. Accidents due to overwinding naturally increased with more rapid hoisting and some means for preventing these accidents came to be considered more and more of a necessity.

NECESSITY FOR AUTOMATIC DEVICES

Up to this time a few devices had been furnished, but in most cases it was left to the engineer's judgment whether they were to be used or not. Owing to the

* Superintendent of Chicago Works, Sullivan Machinery Co.



The Double Drum Sullivan Hoist of the Port Henry Iron Co., Port Henry, N. Y. Drums 7 feet in diameter, Corliss Engines, 20 x 42 inches.

customary antagonism to new mechanical devices, instead of attempting to make the best of them, engineers frequently disconnected them under the flimsy plea that they made the machine too complicated, and that there was too much for the hoisting engineer to take care of and attend to. A great many engineers and mine managers in those days made the same statements that some of them do to-day: "Give us an intelligent hoisting engineer to run the hoist, and he is the most dependable automatic device that we can secure." We are pleased to say, however, that these ideas are decreasing at a very rapid rate. It can be easily proved that a man's intelligence is not, and cannot be, as positive in action as an automatic machine.

MEN VS. MACHINES

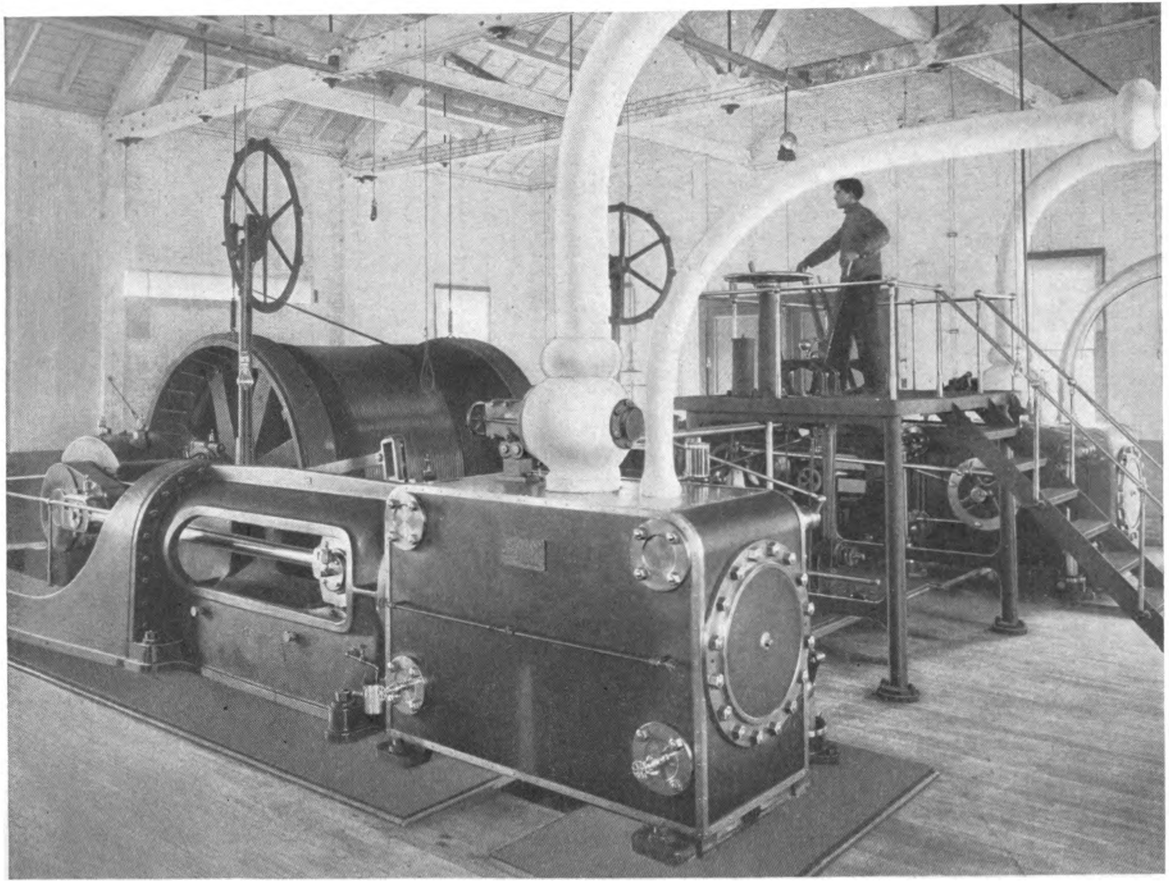
The most efficient machines in use to-day for manufacturing all kinds of merchandise are those which are fully automatic, or as nearly so as it is possible to make them. A great many of these machines are automatic in action to this extent, that when the human being attending them fails to perform the (comparatively speaking) small duties expected of him, the machine will stop, of itself, until it gets the proper attention. In some of our modern up-to-date rolling mills the machinery is so fully automatic that there are only a few men to be seen in an entire mill. The machines operate with such wonderful precision and accuracy that they stop, start, and reverse at exactly the proper moment, which they could not do if their movements were dependent on a human being. The human intelligence is represented in the machine, instead of in the operator, and the operator simply sees to it that the machine is given the proper care and attention in the way of repairs and oiling, so that the intelligence imparted to it by the designer may be utilized without interruption; and there is no reason why a hoisting engine should not be made as fully automatic in all its details as the class of machinery referred to. The time will surely come in the not far distant future when a hoisting engine will be so fully automatic in all of its details that the hoisting engineer can be well-nigh dispensed with.

In order that a man may handle a hoist with absolute accuracy he must act as though he were a part of the machine himself, to close the throttles, to set the brakes, to throw out the clutches at exactly the same time, with relation to the positions of the skips or cages in the shaft, for each trip, and not close them too early, part of the time, and too late at other times. How can it reasonably be expected that an intelligent man should become such an automatic dummy that his arms will move these levers year in and year out without occasional variation? The more intelligent a man becomes, the more interest he takes in life outside of his own employment, in the life of his family, and the welfare of the community in which he lives. A man who is so narrow that nothing but the work at which he is directly employed enters his mind, can scarcely be procured in these days. If men could be secured and broken in who could neither read nor write, or who take no interest in human affairs outside of their own work, they would be the only men that could come anywhere near taking the place of automatic devices on a machine to operate them positively at the proper time; and even that sort of a man would be much more liable to make mistakes and forget himself than an automatic device.

A self-acting machine does not forget anything, neither will it get nervous or mixed up in case of an accident.

EARLY SAFETY MECHANISMS

One of the first successful automatic devices was placed on a Bullock hoisting engine furnished the Montreal Mining



Sullivan Corliss Hoist at the Prince of Wales Mine, Oliver Iron Mining Co., Negaunee, Mich. Engines, 26 x 60 inches; drum, 10 x 10 feet; hoisting speed, 2,500 feet per minute. Drum keyed to shaft.

Company in 1895. Mr. George H. Abeel was at that time, as he is now, general manager of that property. Mr. Abeel is a man who insists that devices placed upon his machinery must be kept up and used. It was not left optional in that case with the brakeman, whether he would be kind enough to make use of these devices, or throw them to one side, after they had been paid for. Their use was insisted on and accidents avoided.

This device was very simple, and consisted of a weight suspended on a hook. When the danger limit was reached an attachment operating in connection with the indicator would detach the weight from the hook. This weight dropped on a lever that immediately admitted steam to the brake cylinders, and placed the automatic cut-off on the Corliss valve gear in such a position that the steam was shut off and prevented from entering the cylinders. The brakes, being exceptionally powerful, would bring the hoisting engine to a standstill in so short a space of time that accidents from overwinding were prevented. The results of these devices were so satisfactory and encouraging that they were placed on several Bullock hoists in various parts of the country.

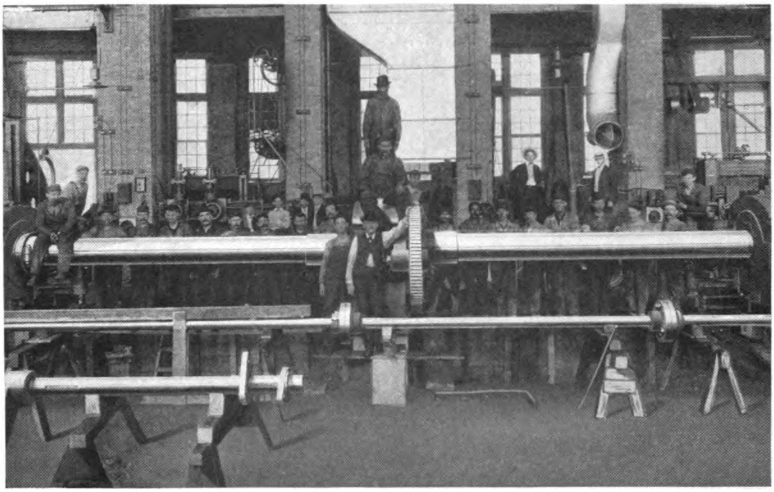
MODERN PRINCIPLES

In 1899 and 1900 the development was begun by this company of a more efficient device for preventing accidents. Hoisting speeds were constantly increasing and the hoisting engines were becoming larger. Some different means for overcoming the great inertia of the moving mass had to be devised, as it was, of course, out of the question to come toward the dump at full speed, then shut off the steam and apply the brakes simultaneously so as to bring the moving mass practically instantly to a standstill. The advisability was then seen of applying an automatic device for automatically closing the throttles at any predetermined point, so that the inertia stored up in the moving mass would be given out in work, and the speed of the hoist so reduced when the danger limit was reached that the automatic brake could be applied and the machine brought to a standstill without shock or jar. The former objections had again to be contended with, so that it was not until 1900 that this scheme was taken seriously under advisement by the more progressive mine managers.

This company has since invented and patented six or seven very efficient combinations of throttle-closing devices and automatic brakes. It has given so much thought and attention to these devices that a dangerous overwind is practically an impossibility where they are used.

Some one not familiar with these devices may ask the question, "In case of a lower boiler pressure than that for which the hoist is intended, if the throttle is closed at the same point as it would be closed if the boiler pressure were higher, will not the engine come to a standstill before the landing is reached?" Regarding this, it should be explained that after the main throttles are automatically closed, the engineer cannot reopen them until the engine is reversed. Should it be necessary to admit more steam to the cylinders, a small by-pass throttle is provided for this purpose, connected with the operator's platform by means of a hand lever or foot treadle.

From this small throttle the steam is conveyed to the main cylinders through a pipe varying from one to two inches in diameter, according to the size of the machine, and a sufficient amount of steam is admitted to the cylinders to complete the lift without increasing the speed of the engine beyond one at which the automatic brake can safely be applied. The automatic throttle-closing device is so adjusted that with the heaviest boiler pressure and the lightest load the engine will come to a standstill, or nearly so, before the point is reached where it is desired to apply the automatic brake and stop it entirely.



A Drum Shaft for a Large Hoist. (38 ft. 10 in. long.)

The by-pass throttle is also very convenient to use instead of the main throttles when hoisting officers and miners or examining the shaft. Due to the small size of the by-pass throttle and the small amount of steam admitted through it, a large hoisting engine can be much more conveniently controlled with it than with the large throttle.

The automatic throttle-closing device is not only a means of safety, but a means of economy as well. A great many hoisting engineers will not shut the throttle until late in the trip, at least part of the time. The hoist is then running at such a speed that the brake has to be applied to arrest the momentum long before the landing is reached, whereas had the throttles been closed several revolutions earlier that much steam would have been saved, instead of being wasted in the neutralization of its energy by the brakes.

Several instances are recorded in which the hoisting engineer has come up to a level, taken on a load, and, by mistake, reversed the engine and lowered the load, instead of hoisting it. The down-going skip pulled the engine backwards at full speed, with the steam admitted to the cylinders in the same direction, thus acting with gravity, instead of against it.

But even though the speed of the machine was controlled by the down-going weight and not by the steam, the automatic brake was applied, and with the exception of breaking a part of the overhead sheave, no damage was done. Had not the automatic brake gone into action the loaded down-going skip would have shot the empty up-coming skip through the top of the shaft house.

SUMMARY

All Sullivan hoisting engines are now furnished with these safety devices. To sum up, they consist, first of a throttle-closing device, which automatically closes the main throttles, at a predetermined point in the hoist on each and every trip. The engineer is *not allowed* to close the throttles; the device interlocks with the engine reverse, so that the engineer cannot reopen the main throttles until he has thrown his reverse lever. The use of the by-pass throttles has been explained above. Second, they have an automatic brake, which goes into action at a prede-

termined point in the hoist, *only* when the engineer fails to operate the brakes from his platform, at the proper time. The action is such that the brake is automatically set, so that the engineer must leave his platform and readjust the automatic brake mechanism before he can release it. There are also a number of Sullivan automatic brakes in operation which are automatically released for the return trip in the same manner as the throttle.

The first plan is considered the better policy, however, so that if anything has occurred to unsteady the engineer, the time needed to go underneath the platform and release the brake will permit him to recover from his nervous shock before he must again operate the hoist.

Hoisting engines that are provided with clutch-driven drums or reels are furnished with devices so that, when each drum or reel is thrown out, the part of the automatic throttle-closing mechanim or automatic brake actuated with the drum disconnected, goes out of use with the drum, otherwise the unclutched drum or reel would shut off the steam from the engine for the drum or reel that was not unclutched.

DIGGING A SEWER WITH HAMMER DRILLS

By George D. Hunter*

In the fall of 1908, the City of Bloomington, Indiana, placed a contract for eleven miles of sanitary sewers, with the Independent Construction Co., of Terre Haute. This work presented many factors of uncertainty, which rendered close figuring difficult, and this concern was practically the only one which submitted an acceptable proposal.

NATURE OF THE WORK

The main sewer consists of two branches which follow the course of two ravines, joining in the southern part of the town. The outlet runs along the bed of a small stream (page 268), for a mile and one half from the business district, to the sewage purification plant, to consist of a settling tank and filter beds, having a daily capacity of 500,000 gallons (page 269).

The mains range in size from 8 to 24 inches, so that the trenches are only 2 to 3½ feet in width. They average 6 feet in depth, with a maximum of 13 feet in the center of the city. One thousand five hundred feet of 12 to 18 inch pipe is laid in the bed of a creek or "branch,"

*Bloomington, Indiana.

the trench averaging 3 feet in depth. In this section the pipe is laid in and covered with portland cement concrete (see page 268). A feature of difficulty on this section is presented by a number of small culverts, through which the sewer is laid, without disturbing the surface of the ground. One of these is 300 feet long and 4 feet high, and three others, 60 feet each in length, with a semicircular cross section 4 feet high at the center. The line of the sewer was against the abutment, as shown in the small sketch (page 267).

Bloomington is in the oölitic stone district of Indiana, and in practically the whole length of this sewer system, solid rock is ecountered below clay from two to four feet deep.

The rock encountered varies from soft oölitic limestone to a bastard stone so hard that it wears the drill bits rapidly. The irregularity of the formation presents other difficulties, since the solid stone is

Sullivan "D-15" Drills in the Trench.

interspersed with boulders, gravel, and mud seams. In many places the surface to be excavated is covered with three to six inches of water. The depth of rock to be excavated averages from two to four feet.

METHODS OF OPERATION

Work was begun under the direction of Mr. W. H. Harris, manager for the contracting company, about September first. The clay was removed in the ordinary way, and twelve Sullivan D-15 hammer drills were installed to drill holes in the rock, for blasting. These drills were selected on account of their small size, which permitted them to be handled readily by one man in the narrow trenches and in the small culverts mentioned above.

This tool has a cylinder diameter of 1$\frac{5}{16}$ inches, and weighs 20 pounds. For work of this character it is equipped with a hollow steel, through which a part of the exhaust is discharged to clean the hole of dust and mud. The hexagonal shank of the steel fits a hexagonal bushing in the drill, and rotation is performed by turning the whole drill with a double grip handle. The throttle is opened by pushing this handle against the drill cylinder, and closes automatically when pressure is released.

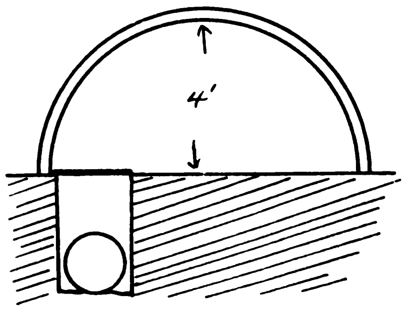
The hammer drills (see pages 266 and 268) put in holes 18 inches to 4 feet deep with one length of steel, the "rose" or eight-winged bits being dressed to 1$\frac{1}{8}$-inch gauge.

The contractors have drilled holes 4 feet deep with these drills, and under favorable conditions have sunk 3 foot holes in 2$\frac{1}{2}$ minutes. The average rate of drilling has been 40 18-inch holes per drill per ten-hour shift, or 60 feet of holes.

The best record thus far is 100 holes, or 150 feet of drilling, in a single shift. Thirty-six 3$\frac{1}{2}$-foot holes have also been drilled by one machine in seven hours. The unevenness of the rock and the mud seams cause some delay in drilling, and the presence of water offers other difficulties; but these troubles are considered by the contractors to be much more than offset by the ease of handling the machines and their high capacity in ordinary conditions. This work has demonstrated that wet holes are not a bar to the successful operation of this type of hammer drills, in which air is used to clean out the cuttings.

The holes are usually placed at intervals of 18 inches along the ditch. First a center hole is drilled, then two side holes, then a center hole again. The distance between the side holes is equal to the diameter of the pipe. The holes are generally carried from eight to twelve inches below the flow line of the sewer.

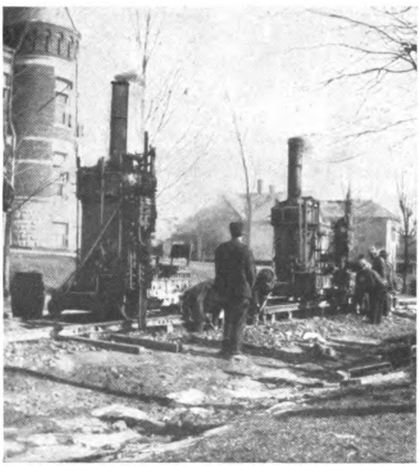
Sixty per cent dynamite is used for blasting, in $\frac{7}{8}$-inch cartridges. The charge varies from two to six ounces per hole. This usually breaks the rock up small enough to be readily shovelled out. In order to prevent danger from flying rock, screens or lattices of two-inch plank are employed. These are placed over the portion of the trench to be blasted, and wooden poles are piled on them. This device allows the powder gases to escape, but catches the broken rock (See page 269). Part of the stone is crushed for use at the purification plant, but most of it is waste, which is removed from the streets.



The Culverts and Sewer Trench.

Laying Pipe in Concrete.

Drilling alongside the Bloomington Gas Works.



Sullivan Channelers Opposite the Court House.

The Creek or "Branch."

Air for the drills is supplied at 110 pounds gauge pressure from two single-stage compressor outfits, one driven by steam and one by belt, from traction engines. Each plant supplies air for six drills, and is moved to a new location when the drills reach a distance of 1,500 feet from the compressor. (See page 269.)

A small reheater, improvised from an oil stove, is provided at each hammer drill, and materially increases the efficiency of the plant.

The Purification Plant.

CHANNELERS

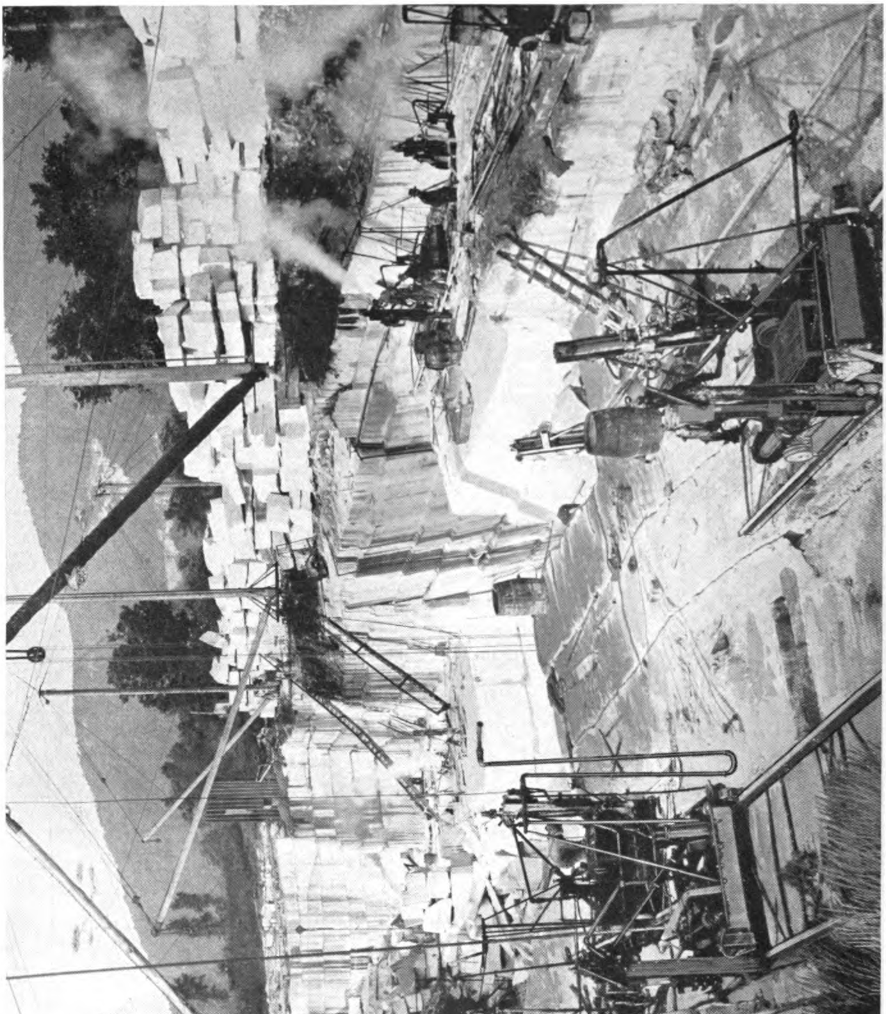
Page 268 shows two Sullivan track channelers, which were installed when the work began, to put down the heavy rock cuts in the center of the city. It was expected to find solid oölitic stone here, but instead the rock was very irregular and hard, interspersed with mud seams and boulders. The channelers were therefore replaced by hammer drills, which did the work satisfactorily.

The work described above is now more than half completed. The total cost of the work to the city will be $100,000, including the purification plant.

Acknowledgment is made to Mr. W. H. Harris, secretary and manager of the Independent Construction Co., for data and photographs. To Mr. Harris is due much credit for ingenuity in solving the problems encountered in this enterprise.

Preparing for a Blast.

The Air Compressor Outfit.



Valley Quarry of the Norcross-West Marble Co., Dorset Vt.

VERMONT MARBLE

PART I. QUARRIES OF THE NORCROSS-WEST MARBLE CO., DORSET, VERMONT

By Ernest H. West

[The Vermont Marble deposits fall into two groups: those which lie practically horizontal, have little overburden to be removed, and are developed from the surface; and those which pitch at an angle into the hills, are covered by heavy layers of worthless rock, and must therefore be worked somewhat on a mining basis. The methods employed in quarrying are quite different in each case. It has been thought wise to describe each class of deposits and the methods peculiar to it in a separate article. That which follows will illustrate the first class; a second article, to appear later, will describe the quarries in and about Rutland, Proctor, Fowler, etc., which fall in the second class mentioned above.— Editor.]

Vermont has long been pre-eminent as a marble-producing State. This fact is strikingly illustrated in the United States Government Report on Mineral Resources for 1906, in which the statement is made that "Vermont produces the greater part of the marble of the United States, the value reported in 1906 being $4,576,913, or 60.36 per cent of the total output of the United States."

Much of the marble from Vermont used in building operations in recent years has come from Dorset, from the quarries operated by the Norcross-West Marble Co. This deposit was originally opened in 1785, making it the oldest marble quarry on the continent.

DURABILITY

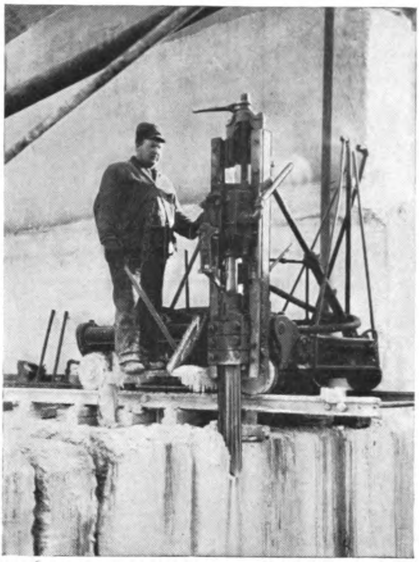
Work was carried on upon a small scale for many years, the output being largely used for headstones. These demonstrate the hardness and durability of the Dorset marble, for although exposed for over a century to a severe climate they are still uninjured. In fact, specimens taken from exposed ledges almost anywhere in Dorset show no signs of decomposition 1/16 of an inch from the surface. This remarkable durability is accounted for by the fact that the marble is of a most compact and brilliant crystalline structure and contains over 98½ per cent of carbonate of calcium.

REPORT OF EDWARD HITCHCOCK, SR.

In 1860 the famous geologist, Edward Hitchock, Sr., president of Amherst College, called general attention to the deposit as follows: "It furnishes the beautiful white marble, equal to Italian, known all over the country as a product of this state. The fine mountain Mt. Aeolus, known generally as Dorset Mountain, contains the most remarkable deposit of white and gray marble in New England and perhaps in the United States. The strata are here piled one upon another to the height of nearly 1,800 feet, in a nearly horizontal position and capped by a few hundred feet of talcose schist. We cannot resist the temptation to apply a name euphonical and appropriate to this elegant rock, so like the Carrara marble. If the proprietors of the marble quarries on this mountain yield to a similar temptation, "Aeolian" marble may become as famous in the future history of this country as the Carrara marble has been in that of Italy."

RECENT INVESTIGATIONS AND OPERATIONS

Quarrying was carried on more or less continuously for over a century in different openings on Mt. Aeolus and in the valley below, the channeling being usually done by hand. It was not until 1902, when the Norcross-West Marble Co. was organized, that operations were commenced on an extensive scale. At this time the present owners gained control of about 1,500 acres of land and began investigations which revealed a tremendous



A Sullivan "Class 6½" Channeler in the Dorset Quarries.

deposit of marble at the foot of Mt. Aeolus, covered over with from only 3 to 12 feet of dirt and gravel, the layers being nearly horizontal.

Forty test holes were put down over widely separated points of the area, to an average depth of 100 feet. Although cored directly across the grain, many of the cores obtained were over 20 feet long, showing a deposit of building marble of unusual extent and soundness.

While there is doubtless a great depth of marble on this property that has never been penetrated by a core drill, it is possible to determine approximately the amount of stone in the investigated area. Figuring on this basis alone, it reaches the enormous total of four billion cubic feet.

EQUIPMENT

The quarry is now equipped with a modern and complete plant, consisting in part of 19 Sullivan channelers, Class "6½," 6 Sullivan gadders, 7 derricks of from 20 to 50 tons capacity and boilers generating 400 horse power. A railroad six miles long was built to Manchester, Vt., to connect with the Rutland R. R. At this place a well-equipped mill of 16 gangs of saws was constructed with a 35-ton traveling crane, 550 feet long.

With this equipment the output from this deposit has run as high as 560,000 cubic feet in one year.

METHOD OF REMOVING BLOCKS.

The introduction of Sullivan quarry machinery her ehas so revolutionized quarrying, reduced the cost of production, and made possible structure heretofore unattainable, that it may be interesting to describe the methods used in laying out the work and in removing blocks from this deposit.

In an important building, plans are first drawn showing exactly the sort and sizes of stone required. Inasmuch as the economical quarry block is ordinarily much larger than the finished stone in any given structure, the quarry block is gotten out to make several of the smaller sizes. Having ascertained the size of the blocks desired, the channeling of the quarry floor is begun. In this deposit, as has already been stated, the layers of marble lie in a nearly horizontal position, making it comparatively easy to lay the track so that the machines will have a level plane on which to operate.

The accompanying photograph shows a Sullivan Channeler, Class "6½" in operation. The machine, driven by steam power, moves back and forth over the track at a rate of about 22 feet per minute. On one side may be seen the cutting tool, consisting of five drills, attached to the piston, the stroke being dealt directly by the steam pressure in the cylinder. In ten hours one of these machines has cut in Dorset marble, channel 30 feet long and five feet deep. a In this manner the entire quarry floor is cut into strips, a channel being also made at each end. One of the strips is then cut up into key blocks, viz., blocks channeled all around.

The first block to come out is usually split off from the main deposit by driving wedges down beside the stone. After it is thus released, a Lewis pin is put into the top of the block, making it possible to effect a "hitch," so that the stone may be hoisted to the surface.

A series of drill holes about eight inches apart is then drilled under the next key block with the Sullivan gadder and the stone split off from its bed by "plugs and feathers" driven by heavy hammers into the drill holes. Then, by means of a quarry bar the block is gradually pried up, until it is raised high enough to permit a chain to be passed around underneath it, when it is hoisted to the surface. When all the key blocks have been removed, the next long strip of marble is drilled by the Sullivan gadder into the desired sizes. The photograph below illustrates how one of these machines works.

The boring apparatus is attached to a perpendicular guide bar, upon which it may be raised or lowered for the purpose of putting in a series of holes in a perpendicular line, a rapid revolving movement being communicated to the drill spindle by the gearing. If desired the guide bar may be adjusted to any angle and the drill swiveled on the standard so as to cut in any direction. A small jet of water is turned into the drill hole to wash out the borings and prevent the drill head from heating. The usual feed of a Sullivan gadder in this stone is 10 inches per minute.

When the "gadding" is completed the long strip of marble is released by "plugs and feathers," and then in the same manner broken up into the desired sizes.

One of the quarries operated by the Norcross-West Marble Co. is known as the "Plateau," and is famous for producing very large blocks of sound marble. The photograph (page 274), shows three 42-ton monoliths recently shipped.

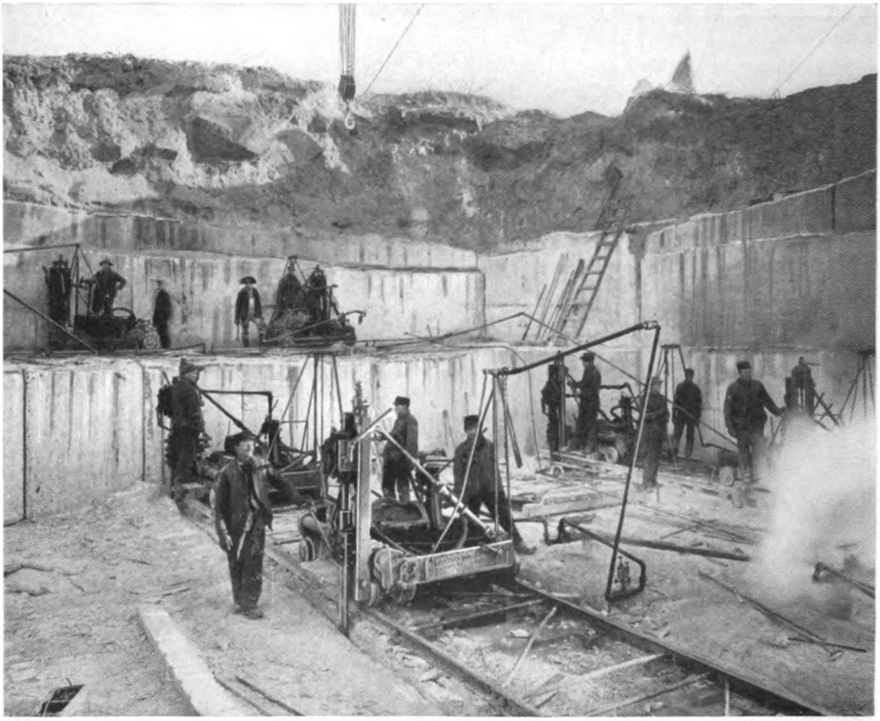
In most marble deposits it is very difficult to obtain sound blocks of this size. At the "Plateau," however, the size of a sound block that can be obtained, is limited only by the facilities for lifting it. Often in this quarry perfectly sound blocks weighing 300 tons are raised from the quarry floor and afterwards broken up into smaller sizes. Thirteen monoliths like those in the photograph are now being furnished for the D. A. R. Building at Washington, D. C.

The facilities for handling the marble are most complete, the blocks being loaded directly onto the cars from the quarry, by derricks of 50 tons capacity.

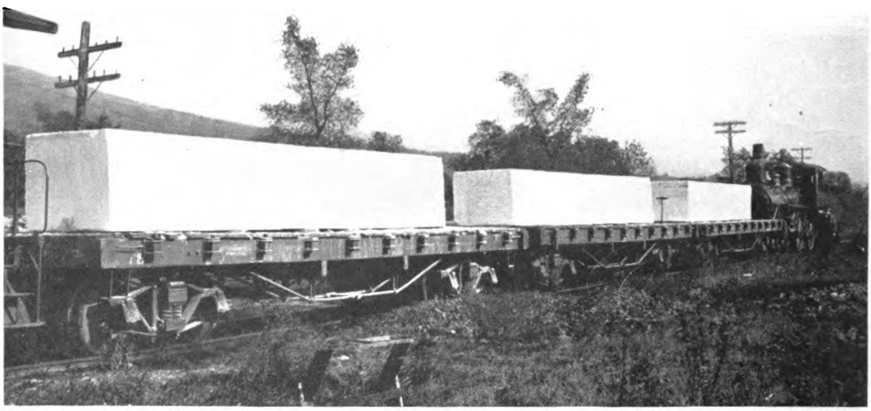
VARIETIES OF DORSET MARBLE

The Dorset marble is largely "Commercial White," but the Norcross-West Marble Co. produce four varieties, viz., "Dorset White," 500,000 cubic feet of which was used in the exterior and interior of the New York Public Library; "Dorset Plateau," as used in the Harvard Medical School Building, the group requiring 220,000 cubic feet of the material; "Dorset Dark Green Veined," as used in the interior of the American Trust & Savings Bldg., Chicago, Ill., and "Dorset Aeolian," as

Sullivan Gadder at Work; "Plugs and Feathers" in the Foreground.



A Corner of the Plateau Quarry, Norcross-West Marble Co. Sullivan "Class 6½" Channelers.



Three 42-ton Blocks from the Plateau Quarry.

used in the interior of the Mass. Mutual Life Bldg., at Springfield, Mass.

BUILDINGS NOW BEING CONSTRUCTED OF DORSET MARBLE

This company is now furnishing the marble for the following structures: Exterior of Continental Hall, completion of D. A. R. Building, Washington, D. C., exterior of the Agricultural National Bank, Pittsfield, Mass., exterior Boston Trust Co. Bldg., Boston, Mass.; exterior John Hay Memorial Library, Brown University, Providence, R. I.

Among other buildings in which Dorset Marbles have been used, are the Royal Bank of Canada, Toronto, Plaza Hotel, New York; Slater Building, Worcester, Mass.; Temple Adath Israel, Boston; Catholic Church, Rockville, L. I., Metropolitan Savings Bank Building, Baltimore, Md.

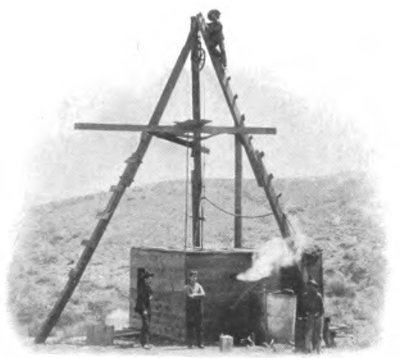
A DEEP DIAMOND DRILL HOLE

Bisbee, Arizona, has in recent years seen much activity in the prospecting and proving up of its mineral formations with the diamond core drill. This is perhaps due to the fact that Lake Superior mining men have become largely interested in the development of Arizona's copper resources, and as diamond drilling is an article of faith in the Michigan copper and iron country, its use in the newer field has resulted naturally. Prior to the advent of Michigan capital, however, some of the older companies had employed diamond drills for many years. The first diamond drill used in Arizona was installed at Bisbee over twenty years ago. This drill was put to work at systematic exploration, nearly all from mine workings. It is said that there is no mining company in the United States better posted than the Copper Queen in regard to the mineralization of its property, both that under development and that which is not yet opened up. This information has all been secured by the thorough use of diamond drills.

The later companies have all resorted to diamond drilling, from the surface, to determine the best place for their shafts, or from under ground, to prove up the exact location and extent of the ore bodies. The results gained have given fresh and continued proof of the accuracy of diamond drills for exploring work.

The most recent center of drilling activity has been on the property of the Warren Realty & Development Co., and on that of the American Development Co. The former company has recently finished a hole 3,200 feet in depth, which is the deepest diamond drill hole yet bored in the United States. This hole was put down vertically on the flat ground about half way between Bisbee and Osburn Junction, a few miles southeast of Bisbee. It required one year and ten days to complete the hole, working one nine-hour shift per day. About two weeks' work was lost in repairs not chargeable to the drilling.

The drill used was a Sullivan Class "C," single-cylinder, hydraulic feed drill, having a rated capacity of 1,500 feet and removing a 1⅛-inch core. When work was begun it was not the intention to go to such a great depth, or a larger drill would have been installed. The "C" machine performed the work satisfac-



The Diamond Drill Shanty.

torily, however, the only trouble caused by the severe overload being the breakage of a gear stand, which was easily remedied.

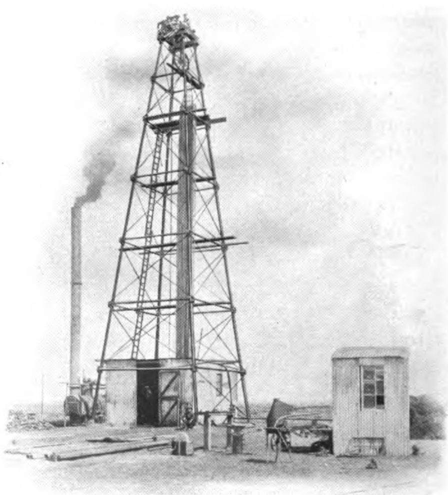
THIS HOLE WAS STRAIGHT

The drilling of this deep hole involved some interesting features. Diamond drills have received more or less criticism from time to time on account of the deviation of the hole from its true course under certain conditions. Some writers have gone so far as to say that drill holes would deviate in any case, whether conditions outside of the drill were favorable for this action or not. Others devote much space to the subject of deviation and of methods for measuring it. This particular borehole was perfectly true from top to bottom. At its completion it was tested several times with a clinometer, consisting of a closed glass tube about half full of hydrofluoric acid. This instrument was placed in a metal tube, carefully sealed to exclude water, and lowered in the core barrel to the foot of the hole. After waiting a half-hour or longer, it was removed. The acid in each case etched a horizontal circle onthe glass, showing that the tube had maintained a vertical position.

The time required to hoist or lower the rods at the final depth was two hours and one quarter. The rods were pulled 20 feet at a time, by means of a single sheave, and lowered with the engine. In the course of the year's work five ⅝-inch first quality steel ropes were worn out. A timber derrick 36 feet high served to pull the rods. For the first 580 feet the drill bits had to be reset about every 8 feet. Below that depth more favorable ground was reached, so that a size "A" bit ran for 30 feet, on an average. Eight carbon were used, being set with 1/64-inch clearance. Care in setting the bits evenly and with a small clearance was probably responsible for the success of this hole. It has often been noted that excessive clearance results in more or less serious deviation. In fact, in the case of a number of deep-bore holes in South Africa, in which serious deviation from a true direction occurred, it was observed in each instance that the diamonds had been habitually set with an excessive clearance.

Mr. Hoval A. Smith, manager of the mining company, gives the following information regarding the progress of the work:

Standpipe was driven through 38 feet of surface drift, and the casing secured by drilling it 4 feet into the rock. Soft ground was encountered at several places down to 580 feet. Instead of reaming out the hole and casing it, to overcome the trouble, the cementing method was employed. After drilling as far as possible in the soft ground, cement was pumped down through the rods, the rods pulled, and the cement left to harden until the next day. This cementing kept the hole tight, and secured return water as far as 580 feet. In the lower part of the hole the water gradually decreased and at last failed to return at all.



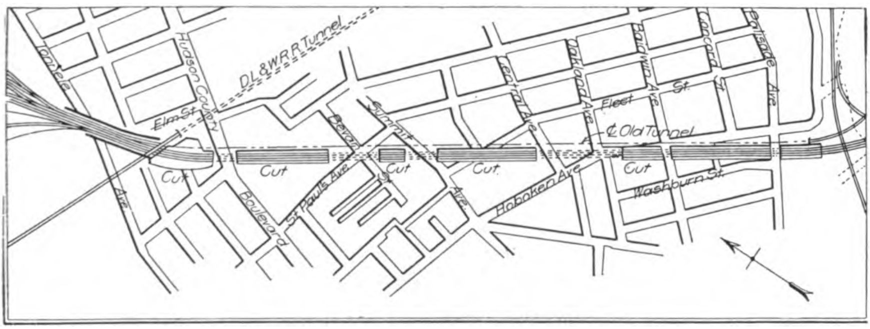
A Sixtv-foot Steel Derrick in South Africa, over a Sullivan "P" Drill, boring a 5,582 foot hole.

As the core was good, however, no effort was made to get the water back. Power was supplied by a 20 horse power upright boiler. The water supply was plentiful, being taken from a near-by flume.

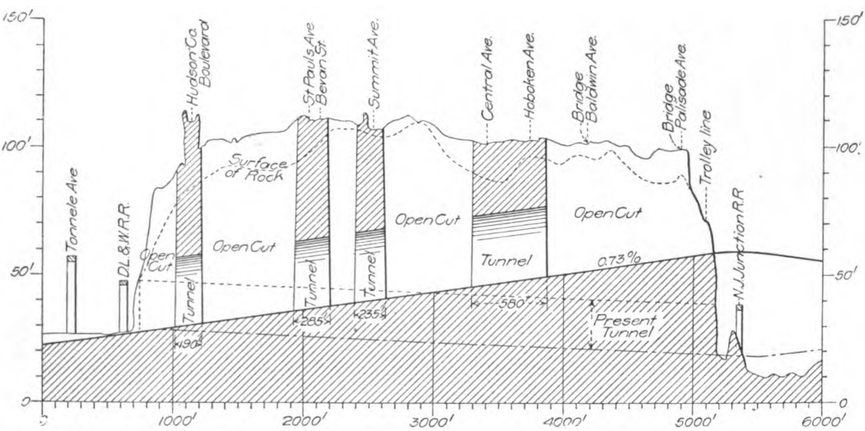
Prior to this time the deepest diamond drill hole in America was one bored to a depth of 2,500 feet, in 1899, jointly by the Geological Survey of Missouri and Swift & Co., at Forest City, Mo. This work was done under contract by the Sullivan Machinery Company.

The Transvaal goldfields in South Africa are the location of most of the very deep holes bored in recent years, in the endeavor to prove the persistence of the reef at increasing distances from the surface. A number of holes have been bottomed during the last five years at depths ranging from 3,000 to 5,000 feet, and at least three have gone to depths of more than one mile, viz., 5,560, 5,582, and 6,340 feet, respectively. For this heavy drilling the Sullivan Class "P" (4,000-foot) or Class "K" (5,000-foot) drills were used. The rods were hoisted in 50-foot sections, with double sheaves. A mile of rods required about eight to ten hours constant labor for removal from the hole.

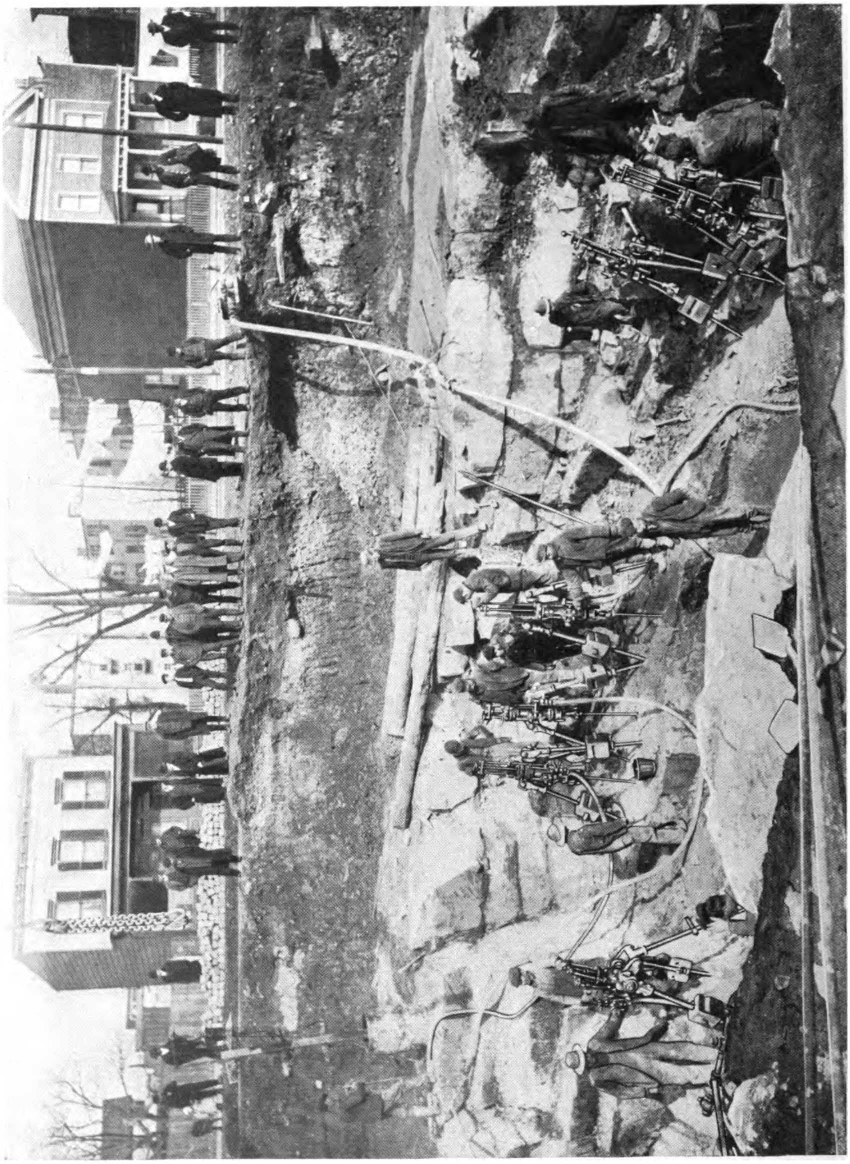
Information for this article was also received from Mr. Louis Buese, of Republic, Mich., who was in charge of the drilling operations.



New Four-Track Line of the Erie Railroad through Bergen Hill.



Profile of the Four-Track Line through Bergen Hill.



Starting the Shaft near Hoboken Ave. with Sullivan Drills, March, 1908.

THE BERGEN HILL TUNNEL OF THE ERIE RAILROAD

By Samuel Seaver *

The Erie Railroad Company is at the present time improving its Jersey City terminal by the construction of a four-track approach through Bergen Hill, the extension of the Palisades which forms such an obstacle to railroads entering New York from the west. This hill, 100 feet high and 4,000 feet across, hitherto has been traversed by the Erie system through a double-track tunnel. For some time this has been inadequate to handle the heavy freight, suburban, and through passenger traffic imposed upon it.

The new four-track system is being constructed for passenger traffic only, reserving the old tunnel for freight. The new approach is 67 feet south of the old, on a different gradient, as shown by the sectional view (page 277), to avoid confusion of traffic at the depot.

An elaborate system of grade separations and junctions at the western end of the approach will enable the trains of the numerous divisions to be received and despatched without delay or interference.

CHARACTER OF EXCAVATION

The new tunnel is in reality a combination of open cuts and tunnels, as shown by the cuts on page 277. There are to be four tunnels, ranging from 190 to 580 feet in length, and 64 feet in width. The entire cut is 4,450 feet long, with a maximum width, at the top, of 100 feet, and a depth of 40 to 75 feet. There will be excavated about 114,000 cubic yards of earth, 420,000 yards of rock from the open cuts, and 79,000 yards by tunneling.

It would have required less excavation to drive one continuous tunnel, but many considerations rendered the combination plan advisable. Among these factors were the difficulty of driving such a wide heading, the greater comfort of the passengers, owing to light and freedom from smoke, and weakness of the rock at many points.

* 42 Broadway, New York.

The higher cost of excavating open cuts is partly offset by the salvage value of the fine Bergen Hill trap rock. Tunnels were adopted for the street crossings, to prevent disturbance of street traffic in Jersey City Heights, and to avoid removing water, gas and sewer mains. At Baldwin Ave. and Palisades Ave., however, bridges are to be erected, and weakness of the roof has also made necessary a bridge at Central Ave., instead of a tunnel.

The Millard Construction Co., of Philadelphia, are the contractors for all of this excavation. They have a very complete plant in operation, and have adopted interesting methods of performing the work.

OPEN-CUT EXCAVATION

In carrying out this work, shafts were sunk at each end of each tunnel, in order to start the headings as soon as possible, and intermediate shafts in the open-cut sections, to reach the grade line at these points. By sinking these latter shafts, deep holes can be drilled and the face worked in both directions. This method enables the contractor to work a larger number of units at the same time. Less powder is required to shoot the rock, on account of the additional free working face, and blasting is performed with much less danger to the present tunnel.

ROCK DRILLING

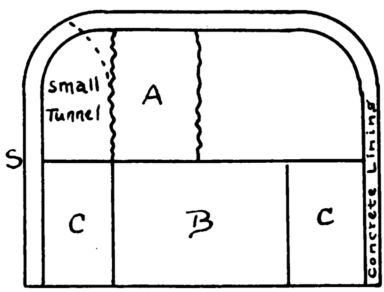
The rock encountered throughout this work is an exceedingly hard trap, similar in appearance to a fine-grained gneiss, but full of seams, or "blocky." Fifty-six Sullivan "UH-2" (3⅝-inch) differential valve rock drills are used for all the heavy drilling work, being mounted on columns for tunneling and on tripods for open-cut and bench holes. In working the faces

in the open cuts, vertical holes only are used, breaking the ground from the top of the cut. These holes are drilled from 14 to 16 feet in depth. The air reaches the drills at about 90 pounds pressure.

The steel has a finishing gauge of 1⅜ to 1½ inches, and regular cross bits are used, formed and sharpened on a machine drill sharpener. Owing to the extreme hardness of the rock, the wings or corners are maintained for about an inch back of the face, to prevent rapid wearing of the gauge.

The powder used is 1¼ inch, and all shots, both in the open cuts and in the tunnels, are fired by blasting batteries, according to eastern practice, instead of spitting the fuses by hand, as is customary in western mining tunnels.

The cuts on pages 278 and 282, show the tripod drills in operation, and the nature of the rock encountered. Rock fragments too large for the crushers are broken up by block holes from one to two feet deep. These holes are bored with Sullivan "D-19" hand feed air hammer drills, using hollow steel (see page 284). These drills weigh 30 pounds. A part of the exhaust is directed through the hollow steel to clean the holes, and rotation is secured by a hexagonal drill shank and bushing, the drill and steel being turned by a wide double-grip handle. This has proved a very economical way of handling this part of the work.

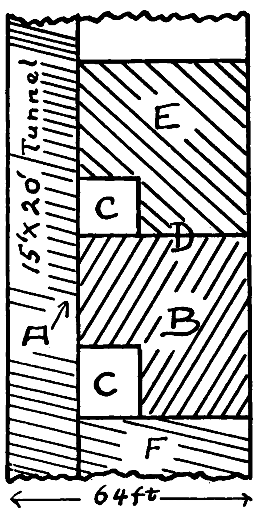


Cross-section of Tunnel.

TUNNELS

All the tunnel sections have a width of 64 feet. They are driven according to a special plan, made necessary by their great size. Headings are first carried above the spring line, and on the wall farthest from the old tunnel, to avoid danger to traffic. Page 281 shows the entrance to one of these headings. They are next enlarged into tunnels 15 x 20 feet, as shown by the sketches, on this page. The portal of the main tunnel is then carried in full section for 15 or 20 feet above the floor line of the small tunnel. The drills are now mounted on columns at "A," and the shaded portion "B" removed, leaving a supporting pillar "C." (Second sketch.) The drills are again set up at "D," removing section "E," and again leaving a pillar. This process is repeated until the whole heading is widened. The benches "C," are then excavated, leaving a core "B," 20 to 30 feet wide, to support the pillars and the additional wooden props which are needed. (First sketch.)

At this stage the first section of concrete lining will be placed, extending up to the



Plan of Tunnel at Spring Line.

West Portal of 15-foot Tunnel under St. Paul's Avenue.

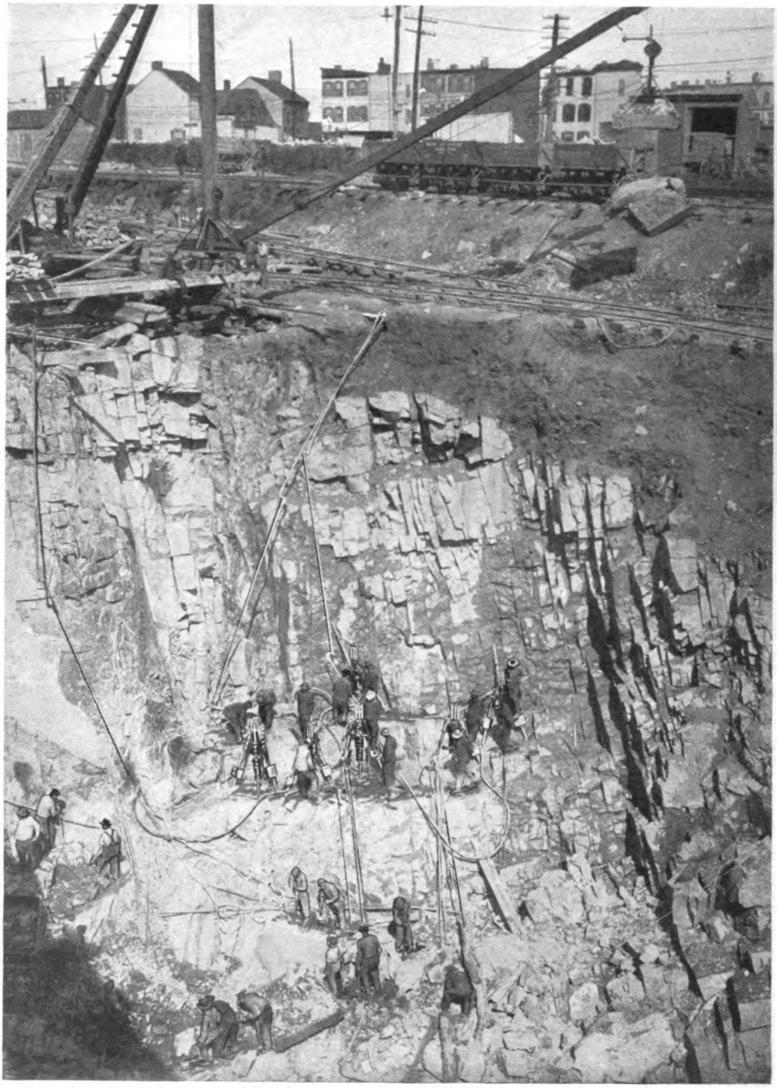
first pillar. This lining will be left to harden while the concrete crew is at work on the other tunnels. The first pillar and the core "B" will then be removed, as far as pillar number 2, the walls and roof lined with concrete, and the work continued in this order of rotation.

In driving the headings, four Sullivan "UH-2" drills are used, two each being mounted on eight-foot double screw columns. The benches are taken out by drills mounted on tripods, which remove them to grade line in two lifts.

DISPOSITION OF SPOIL

The broken rock is handled by movable derricks at the faces of each heading, and by stationary ones at the surface. Two steam shovels are in constant use. Overhead cableways are suspended across the cut at many points, operated by stationary air engines or electric motors at the sides of the cut.

A three-foot gauge track runs on the surface the full length of the cut, for removing the spoil. A temporary tunnel under Hudson County Boulevard prevents interruption of traffic there. The earth is carried to the Hackensack meadows for embankments, and the rock is hauled to a large crushing plant at the western end of the work. One hundred and twenty-five four-yard dump cars and eight industrial locomotives are used for this purpose. Page 283 shows the character of the work from St. Paul's Avenue west to Hudson County Boulevard, marked by the stone wall in the background. The conical building at the left is an air shaft for the old tunnel, and shows how close the two lines are to each other. The two cuts shown have been carried down to grade, leaving only the central 50-foot strip on which the derrick is placed.



Shaft between Summit and Central Aves. This cut shows the very blocky character of the rock.

Looking West from St. Paul's Avenue to Hudson County Boulevard.

Page 284 shows the large stone pile, over 500 feet wide at the base. The rock is dumped, by an air cylinder, into a No. 10 crusher, whence it passes to four No. 6 crushers, which reduce it to 2½-inch size. It is then carried to the stone pile on a 410-foot belt conveyor, which rises to a height of 75 feet. The stone is distributed by a stacker and another adjustable conveyor, with a travel of 700 feet. A large part of this pile has since been removed for use as ballast on the Erie's road bed.

POWER PLANT

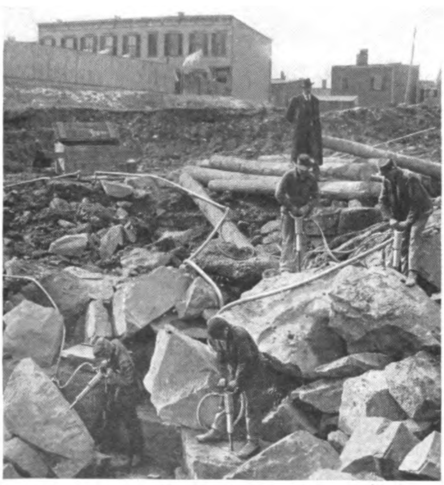
The power house, compressor plant, and repair shop are also at this point. A 500 horse power cross-compound engine drives the crushers and conveyors, except those on the stone pile. The three cross compound air compressors deliver air for about 70 drills to a riveted pipe line running the entire length of the work. The steam plant consists of four 500 horse power water tube boilers, equipped with a feed water heater, and a fan for forced draft.

PRESENT STATE OF THE WORK

The work of excavation has been somewhat slower than usual on such undertakings, owing to the precautions taken to avoid accident to the old tunnel. Until recently, blasting was permitted at only three times in the 24 hours, when the traffic was at its low points. When permission to blast was given, no trains were allowed to enter the tunnel until the shooting was over, and until an inspection car had been run through the tunnel to make sure that the walls were not affected. Blasting is at present allowed at any time.

The open-cut excavation is now (February 1) about half completed, and the tunnel work about 25 per cent finished. All of the small preliminary tunnels are done, and the widening to full section of the tunnel above their floor line is finished

The Crushed Stone Pile and Conveyors.



Sullivan "D-19" Foot-hole Drills, Block Holing on the Erie R. R. cut, Bergen Hill.

in the tunnels under Hoboken, Central and Summit avenues. It is progressing rapidly under Hudson County Boulevard and St. Paul's Avenue.

The Millard Construction Company were fortunate in securing the services of Mr. John Hendrie as their superintendent on this work, as he has had a very wide experience in tunnel and open-cut work, especially in railroad contracting jobs. Having had charge of the western section of the new Pennsylvania R. R. tunnel, recently completed through Bergen Hill, he is extremely well posted on the peculiar nature of this rock and the difficulties to be overcome.

The writer acknowledges to Mr. Hendrie assistance rendered in preparing this article. Some of the general data and sketches which are used first appeared in the Engineering Record of April 18, 1908.

INDEX

Volumes I - III

PAGE

Air Compressor, A New 52
Air Compressor, A Straight Line Corliss. H. A. Wainwright 163
Air Compressors, Care of Discharge Valves for 84
Air Power Economy in a Granite Quarry ... 213
Alabama Marble 246
Amherst, Ohio, Quarrying Sandstone at 48
Ashokan Dam, Progress on. J. H. Brown, Jr. 251
Atchison, Topeka & Santa Fe Railway, Second Raton Hill Tunnel of. W. P. J. Dinsmoor 225
Bergen Hill Tunnel of the Erie Railroad. Samuel Seaver 279
Black Diamonds, Origin, Production and Use 64
Bridge Foundations, Testing for. F. H. Bainbridge 240
British Columbia, Cost of Diamond Drilling in. Frederic Keffer 210
Carthage Limestone. R. S. Strong 179
Channeler, Tunneling with a 91
Channeling in New York City. J. H. Brown, Jr. 42
Chicago Drainage Canal, Power Extention of. 11
Cleaving Granite by Compressed Air 23
Coal Mining Machine for Low Veins 255
Coal Prospecting, Progress in. J. A. Wentz . 45
Cobalt, Mineral Prospecting at 137
Compressing Air for Drills, Low Cost of 23
Conveyors, Mechanical, as Applied to Longwall Mining. J. I. Thomas 193
Cutting Coal, Amount of Power Consumed in 108
Deep Diamond Drill Hole 275
Diamond Drilling 9
Diamond Drilling, Cost of 111
Diamond Drilling in British Columbia, Cost of. Frederic Keffer 210
Diamond Drilling at Mapimi. J. F. Bennett 185
Diamond Drills, A Novel Use of 44
Drilling in Colliery Development, Engineering & Mining Journal 45
French Colliery, American Drills in a 92
Granite Quarry, Air Power Economy in 213
Gunnison Tunnel of the Uncompaghre Irrigation Project, M. G. Doll 30
Hammer Drills, Adaptability of. G. H. Gilman 183
Hammer Drills, Channeling Granite with ... 106
Hammer Drills, Digging a Sewer with. Geo. D. Hunter 265
Hammer Drills, Mining with. M. G. Doll ... 171

PAGE

Hoisting Engines, Automatic Stoppage of. S. T. Nelson 259
Hoists, Safety Appliances on First Motion ... 56
Illinois, Machine Coal Mining in 245
Illinois Mine, Modern Methods at an 3
Indian Territory, Coal Mining in the. G. W. Blackinton 166
Indiana, Coal Mining at Bicknell. M. C. Mitchell 129
Joplin Field, Lead and Zinc Mining in the. R. S. Strong 155
Mapimi, Diamond Drilling at. J. F. Bennett 185
Marble in Georgia, Quarrying 58
McCall Ferry Dam, Air Power in the Construction of. L. R. Chadwick 142
Mine Explosion, Photographing a 117
Mine Power Plants, A New Departure in. G. M. Crawford 230
New York City, Channeling in. J. H. Brown, Jr. 42
New York, New Haven & Hartford Railroad Tunnels. H. N. Harding 187
New York State Barge Canal, Excavation Methods on. A. Y. Hoy 54
New York State, Marble Industry in 95
New York Water Supply Aqueduct, Hudson River, Crossing of. J. H. Brown, Jr. 161
New York Water Supply, Diamond Drilling and the 86
Panama Canal, in April, 1907. R. D. Hunter 114
Panama, Rock Excavation at 3
Rock Drills, Suggestions for Operation of ... 28
Rock Drill Bits, Proper Shape for. D. J. O'Rourke 220
Rock Drill Steel, Mechanical Sharpening of. Matt Brodie 104
Safety Appliances on First Motion Hoists 56
St. Mary's River, Improvements in 203
Slate, Economy in Quarrying. A. E. Blackwood 123
Soapstone. G. M. Bertram 149
Southern Ohio Freestone Quarry 75
Tapping Water in Mines 44, 102
Tidewater Railway, Construction Progress on. G. M. Bertram 70
Tunnel Driving, Western Practice in. W. P. J. Dinsmoor 118
Vermont Marble. E. H. West 271
Wabana Iron Mines, Drilling Costs at, etc., Engineering Contracting 76

R. R. DONNELLEY & SONS CO., PRINTERS.